1984 NASA AUTHORIZATION

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BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

OF THE

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1984 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 9, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON TRANSPORTATION,
AVIATION, AND MATERIALS,
Washington, D.C.

The subcommittee met, pursuant to call, at 2 p.m., in room 2325, Rayburn House Office Building, Hon. Dan Glickman (chairman of the subcommittee) presiding.

Present: Representatives Glickman, Andrews, Carney, Boehlert, and McCandless.

Mr. GLICKMAN. The hearing will be called to order.

This is the first hearing of the year for our subcommittee, and we are pleased to have Dr. Kerrebrock before us to talk about NASA aeronautics programs.

We have a newly constituted subcommittee this year, with a new ranking minority member, Mr. Carney from New York. We have Mr. Boehlert from New York, Mr. McCandless from California, as well as several new members on the majority side of the aisle.

So as you go through the program, Jack, you may want to explain things in some degree of depth, as some of the folks have not had a chance to hear some of the origins of the programs. So I would just encourage you to explain it in any way you deem appropriate.

Today the Subcommittee on Transportation, Aviation, and Materials will continue its consideration of NASA's aeronautics program, in general, and its budget request for fiscal year 1984 in particular.

Last December, at a hearing on aeronautical research and technology policy, we received the results of an intensive study by the White House Office of Science and Technology Policy on that subject. The study concluded that continued strong advancement in aeronautical R&T is essential for national security and for continued success of the U.S. civil aircraft industry. Furthermore, Federal support of this effort is necessary because private companies are unable to capture the benefits of long-term, internally funded R&T and are thus unlikely to undertake it.

Today the subcommittee will begin its examination of NASA's fiscal year 1984 aeronautical budget request to see if it responds to those findings. We will be especially interested in whether the budget provides adequate funding for R&T aimed at civil aircraft applications or whether it continues the trend, started last year, toward overemphasis on military applications.

My first reading of the budget is not encouraging. Although the overall budget level shows a modest increase over last year, it appears that militarily related technologies are receiving the lion's share of the funding. Also, several programs, including the Prop-Fan, the TCV, and Laminar Flow Control, that Congress restored last year after the administration eliminated them, are not included in the 1984 request.

So with these concerns in mind, we have asked Dr. Kerrebrock of NASA to describe not only the details of his 1984 request, but also to show how it meets the intent of the OSTP policy statement.

Now, in addition to that, I would make one other final comment.

In the past, we have generally looked at the aeronautics budget on a year-to-year basis, and, while NASA projects funding over future years, I have become concerned that we pay far too little attention to what is going to happen past that 5-year period of time. There is a tendency to approve projects over and over again because funds were spent in the previous year, or perhaps because some company has an interest in a contract with NASA. Some of these programs may be well worth funding; others may not.

But I guess my concern is that, in light of the competition from the rest of the world, the focus of this committee this year should be on the long-term efforts of NASA in assuring that we are preparing for the 21st century in aeronautical research and technology.

Now, I would like to ask my ranking minority member, Bill Carney, for any statements that he may wish to make.

Mr. CARNEY. Thank you, Mr. Chairman.

I am pleased to join you in welcoming Dr. Kerrebrock to the second day of hearings on the NASA budget. The aeronautics program represents a small but very important part of the overall budget.

The study conducted last year by the President's Office of Science and Technology Policy established not only the importance of aeronautics, but also the legitimacy of the Federal role in research and technology. This budget continues to reflect the high priority this administration places on aeronautical R&T. At a time when most programs are being asked to take cuts, the administration is proposing a 7¼-percent increase in the aeronautics budget.

I won't deny that some popular technology programs are missing from the budget and that it won't satisfy everyone. However, the aeronautics program being proposed is a positive, balanced program which puts the emphasis where it belongs: basic research and long-term investments for the future.

The administration is proposing an increase of $30 million, or approximately 15¼ percent, in the R&T base. This is not excessive. It is appropriate that the aeronautics program shift back towards the more basic research and away from technology validation. We must not lose sight of the fact that NASA's primary function and its first responsibility is the basic, fundamental research that will benefit all aviation.

In the area of systems technology, I particularly support the Numerical Aerodynamic Simulator being proposed as a new initiative in 1984. This is the kind of investment in the future that will insure that this country maintains its position of leadership in

aeronautical design. And, clearly, all aviation will benefit from this.

Although this year's budget may not include everyone's favorite program, I believe it reflects an enlightened, progressive approach to meeting the challenges that face us in aeronautics.

I look forward to hearing Dr. Kerrebrock's testimony this afternoon.

Thank you.

Mr. GLICKMAN. Thank you, Mr. Carney.

Dr. Kerrebrock, you may proceed. Your entire statement, of course, will appear in the record, so you may feel free to summarize.

STATEMENT OF DR. JACK L. KERREBROCK, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. RAYMOND S. COLLADAY, DEPUTY ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. KERREBROCK. Thank you very much, Mr. Chairman. I did intend to request that.

Mr. Chairman, and members of the subcommittee, I am pleased, indeed, to present to you today the fiscal year 1984 aeronautical research and technology budget request.

Today, I have with me my Deputy Associate Administrator, Dr. Colladay, Assistant Associate Administrator, and Mr. Nysmith. My division directors are also here, to assist with any detailed questions, as we would like to answer your questions in as much depth as you wish.

The program we are proposing reflects the dedication this subcommittee has shown to a stronger aeronautics program, and I believe it should largely meet your desires for a strong effort in both the disciplinary and the systems activities. We believe it is balanced between in-house activities and participation by industry and academia, and all three of those components are very important. This program together with a vigorous construction of facilities program, to which I will allude very briefly in my presentation, should enable NASA to maintain and enhance the already outstanding aeronautical R&T capability that is represented by its three research centers. And Mr. Carney, we appreciate your concern for that.

This budget request reflects an improved consensus on the role and the scope of federally funded aeronautical R&T, which has been arrived at in hearings conducted by the Congress and in a broadly based study conducted by the Office of Science and Technology Policy [OSTP], which recently culminated in the expression of a national aeronautical research and technology policy, to which, Mr. Chairman, you have already referred. I would like to spend just a few moments to review the high points of this policy, although I will say that they do not differ substantively from points you have already outlined. But, however, I would like to do that before I proceed to a description of the program.

The OSTP report recognizes several things. First, that military and civil aeronautics and, indeed, the health of the aeronautical industry of the United States, are national concerns. Second, there are very large gains to be made in the efficiency and effectiveness of aeronautical vehicles through continued research and technology efforts, and that it is, therefore, essential, for reasons of both military security and the industrial health of the United States, to continue a vigorous research and technology program. If we do not, someone else will, and we will lose the position we now hold in the industry. Third, and to me, perhaps most important of all, it has been established that the aeronautical R&T, which NASA has conducted over the years and which it proposes to conduct in the future, has common applicability to both military and civil aeronautical needs. It is not necessary, therefore, to distinguish between the programs that we conduct for military uses and the programs that we conduct for civil purposes. In very large measure, they have common needs, and one program will suffice. The next point, which you mentioned, is that continuing Government support is essential to the commercial aeronautics industry, and that is because the gains to be made from long-term technological research are not realizable in the short term. Finally, the OSTP study reaffirmed that the present institutional framework is excellent and should be fostered.

In that framework, NASA directs and implements aeronautical research and technology development and supports military aeronautical development programs. We share your concern, Mr. Chairman, for the long view. Because of this, we have been at great pains for the last year to construct, through a cooperative activity between OAST Headquarters and our three research centers, a long-range plan for aeronautical R&T.

This long-range plan emphasizes three elements of the research, which I will characterize as; disciplinary research, by which we mean the generation of basic understanding and the development of new concepts; systems research, by which we mean the study of the interactions between components and fairly basic issues, which are vehicle-class specific; and, finally, proof-of-concept activities, by which we mean assessing the feasibility of advanced concepts. Let me emphasize that all three of these classes of research are included in the category of research and technology development which the OSTP report recognizes as NASA's basic charter. We intend to emphasize those three aspects of the aeronautical R&D endeavor.

Our long-range plan is structured around four key objectives. The first is to maintain the excellence of the research centers in critical aeronautical technologies. The second is to strengthen the NASA-university interaction through greater participation by academic research people. The third is to increase the participation of industrial R&D organizations in the NASA program. This has two purposes—one is to enhance the actual generation of technology through taking advantage of the capabilities in these organizations; the second is to expedite the transfer of the resultant technology into industrial application; and, finally, the fourth objective is to maintain a program which is balanced between the three elements that I mentioned of disciplinary research, systems research, and selected proof-of-concept activities. All of these emphasize on the

common applicability to both civil and military needs. We intend to use this long-range plan as a guide to participants in the program, both within and outside of NASA.

Before turning to the proposed fiscal year 1984 research and technology program, let me briefly discuss our plans for the institution which we feel plays a very important role in the overall picture.

Let me begin with our plans for status (figure 1) and plans for some of our major facilities. Beginning in 1984, our CofF request includes a multiyear repair and replacement program to insure the productivity and the reliability of our major facilities. Some of the recent ongoing activities in the CofF area are outlined here.

The avionics integration research laboratory, or AIRLAB, is now under construction, and should be in operation at Langley Research Center very soon. This facility is doing research on the characteristics of advanced avionics systems which may be incorporated in future aircraft.

The Man-Vehicle Systems Research Facility at the Ames Research Center will be used to do research on the man-vehicle interaction in advanced cockpit systems and consists of two cockpits. One is the 727 cockpit and the other is a very advanced technology cockpit. We expect it to make very large contributions to that important area of human factors. We had planned for the enhanced 40- by 80- by 120-foot wind tunnel to come on line this year. We had a structural failure in the flow diverting vanes which turn the flow from the 80- by 120-foot leg into the recirculating leg of the 40- by 80-foot wind tunnel. This will be delayed by about 2 years.

The National Transonic Facility at Langley Research Center has been undergoing checkout and initial operational activities for some months now. We expect it to be on line and fully operational for initial calibration runs by this summer. It has been operated at room temperature, and it is being cooled down to operate at cryogenic temperatures. In addition to this, at Lewis Research Center we are upgrading the central air pressure system, and the fiscal year 1984 CofF request includes some test cell upgrades and a very important upgrading to the icing research tunnel, which is the national facility for icing research.

The 1984 CofF request also includes modification of the 30- by 60-foot low speed tunnel at Langley and the construction of a fluid mechanics laboratory for basic fluid mechanics work at Ames.

As Mr. Beggs mentioned in his testimony, the centerpiece of the 1984 aeronautics program is numerical aerodynamic simulation [NAS]. This NAS capability includes a computer system which will make it possible to perform many of the three-dimensional calculations required to optimize the design of new aircraft. It will also allow us to gain new insight into the basic structure of turbulent separated flows, the understanding of which is essential to advances in future aircraft and engine design. I will say more about that later.

The total fiscal year 1984 aeronautics request (figure 2) is $300.3 million, as compared to $280 million in fiscal year 1983. Of this, $227.8 million is for the research and technology base and $72.5 million is for systems technology.

I would like to say at this point that the decrease between 1983 and 1984 in the systems technology line is due in large part to the completion of several elements of the ACEE program; among those is the energy efficient engine, which was planned for completion in 1983. The $72.5 million allows for three rather ambitious new starts or augmentations, which I will describe in more detail later.

Let me also emphasize that we have stabilized the manpower. We will have the same number of civil servants in the OAST laboratories devoted to aeronautics, the number shown here, as in 1983, and we regard this as an excellent accomplishment decision.

The program resources of $300.3 million that I have mentioned are in the research and development category, It is important to recognize that those funds are complemented by an allocation of $265 million for research and program management, plus a $24 million CofF budget, which I have described.

The R&D budget is distributed (figure 3) between the research centers. Ames Research Center is allotted 41 percent which includes the Dryden Flight Research Facility and enhancement for NAS; Langley receives 31 percent; and Lewis receives 26 percent. The participants in the program consist of in-house workers, industrial R&D people and people in universities; their shares of the R&D budget are indicated here. It should be pointed out that this R&D money, which supports the in-house activity, by and large, is spent on the outside for equipment, instrumentation, and so forth, to support the in-house researchers, who, in turn, support the industry through their activities.

Mr. CARNEY. Doctor, I beg your pardon, but you alluded to 41 percent. That tells me nothing. I am not a good judge of how much of the pie that is. Now, what is that in-house? About 60 percent, 58 percent? Do you know the figures?

Dr. KERREBROCK. Yes. The in-house portion is 55 percent of the $300.3 million.

Mr . CARNEY. And the industry part?

Dr. KERREBROCK. Forty-five percent for industry.

Mr. CARNEY. I know the university part is 10 percent.

Dr. KERREBROCK. No. It is 9 percent.

Mr. CARNEY. It is 9 percent.

Dr. KERREBROCK. Does that add up right? Make sure they add up to 100 percent.

Mr. CARNEY. I got 110 percent now.

Dr. KERREBROCK. The 45 percent includes the university part, which is 9 percent.

Mr. GLICKMAN. But these numbers do not include any salaries?

Dr. KERREBROCK. No, they do not, just R&D moneys.

Mr. GLICKMAN. All R&D moneys.

Dr. KERREBROCK. That is the reason I made the point that the money that is shown under "in-house" is spent outside, in support of the in-house research activities, for equipment and so forth. Is that clear?

Mr. CARNEY. Yes, sir. Thank you. I did not mean to interrupt you.

Dr. KERREBROCK. No, I think you should, because we want to make it clear.

Mr. CARNEY. In that case, would you give me the figures on the other centers?

Dr. KERREBROCK. I will refer that question——

Mr. CARNEY. If you have them, we will get them later, sir. It will be just as easy, rather than interrupting. Thank you.

Dr. KERREBROCK. I would like to mention that my office has recently been assigned the responsibility for managing NASA's part of the small business innovation research program. I am sure you are all familiar with that. We are currently working toward release of the first solicitation for proposals in the spring, I believe in March. This effort includes all of the activities of NASA, so that aeronautics is only a part of it. But my office is responsible for managing it for the whole Agency. We look forward to this opportunity to add to our industrial aeronautics team a number of small creative groups offering fresh ideas and concepts.

With your permission, I would like to outline our plans for the fiscal year 1984 programs and highlight some of the recent accomplishments. The structure of this presentation is by technical elements. You will not necessarily find a one-to-one correspondence between these and budget items, but we would be happy to explain that in more detail, if desired.

The first one I would like to mention is high Reynolds Number aerodynamics figures, in which the National Transonic Facility is the enabling capability. It will enable us to study the behavior of advanced airframe configurations, such as this model transport configuration, which we call Pathfinder I, at Reynolds Numbers which are equal to those of the full-scale flight vehicle.

Mr. GLICKMAN. Why don't you explain Reynolds Numbers?

Dr. KERREBROCK. Reynolds Number is the nondimensional number which characterizes the viscous behavior of an airplane.

It is limited by the fact that the friction forces the flow velocity at the surfaces to be zero, so that there is what we call a boundary layer between this zero velocity condition and the free stream, or high velocity condition. Most of the phenomena which limit the performance of the aircraft are due to the behavior of that boundary layer, or that viscous region.

The Reynolds Number is the nondimensional number which characterizes the thickness of that boundary layer compared to the width of the wing, or the chord of the wing, as we say, and the Reynolds Number is very large, so the boundary layer is very thin.

The facilities that are available now, prior to NTF didn't come within a factor of 10 of simulating the full-scale flight Reynolds Number. The NTF will simulate the full-scale flight Reynolds Number, which will enable us to get a more reliable estimate of the real behavior of the configuration before it goes into full flight test.

The intent is to do that for a transport type configuration, which is the high subsonic cruise. That configuation will be a benchmark against which we will compare other experiments and flight data. We will go on, then, to other models, such as this Pathfinder II, which is a fighter configuration, but a generic one, not a specific fighter. We will even be able to study the behavior of advanced Shuttle configurations during reentry, this being one of the highest Reynolds Number vehicles around. Up in the righthand corner of

the figure you see a 767 model, which we will use to checkout and compare with flight data.

The next area I would like to emphasize is Airframe/Propulsion Integration (figure 6). We are studying the interaction between the flow field around the propulsion unit, the engine, and the wing, or the body of the airplane. It is a very complicated problem because it is three dimensional. We have the capability now, through the advances in computational fluid dynamics, for studying this problem much more quantitatively than in the past. In the left, is a comparison of a two-dimensional calculation at the top, with a two-dimensional measurement from a wind tunnel. You should compare the shape of these dominant features in the two, and you will see that they are very close. That is what we mean by verification of the wind tunnel data. We are in the process of extending this, and we will do so in 1984 to the three-dimensional nonsymmetrical flow conditions, meaning nonaxisymmetric, and that will put us in a position to reduce the drag of the installed engines, which is a very significant part of the drag of the airplane.

Another area in which computational fluid dynamics should be very helpful is in turbomachinery flow analysis. Figure 7 shows a a comparison between predicted and measured of Mach numbers. Do you know what Mach number is? That is the flow velocity divided by the speed of sound. The Mach number near the surface of this advanced air foil shape is compared with measurements, the dots are the measurements and the curves are the computation.

This type of work already has made a significant contribution to the design of modern engines, such as the Pratt & Whitney 2037, which has an air foil section something like this one in it.

We are now going on to incorporate three-dimensional viscous effects, and the end result of this program will be a capability for designing multiple blade rows with full three-dimensional flow simulation.

Numerical Aerodynamic Simulation will be enabled, by the computational system that is depicted in figure 8. This computational system consists of a number of elements.

First there is a numerical processing system network, or let me say system, which is indicated by the yellow components here to be graphics subsystem, workstations, where the people would work at consoles, mass storage subsystem, a support processing subsystem. All of these are commercially available components. They support a high-speed processor, which we intend to be the most advanced super computer available that is appropriate for this kind of work on a continuing basis. In other words, we are committed to continually replacing that high-speed processor with the best that are available as soon as they become available as prototypes.

There will be a long-range communications link via satellite, with all of the other centers of NASA, to make sure that this is an agency capability, although it will be located at Ames Research Center.

Now, the capabilities this system will offer are depicted in figure 9. Our goal is to have by about 1987 a NAS capability of one gigaflop. Now, I better translate that. That is one billion floating point operations per second.

Mr CARNEY. Faster than my wife can talk.

Dr. KERREBROCK. A floating point operation being a multiply, divide, add or subtract. And it will have a storage of 240 million words. That capability will enable us to do the complete three-dimensional design calculation for a simple aircraft, as indicated here.

We presently have a Cray 1S at Ames and we have a Cyber 205 at Goddard, so we are down in this range, and the first step in NAS will be to get the next generation super computer, which we hope to get in the middle of 1984, which will take us about halfway up this arrow.

High temperature materials have been a key to advances in aeronautical propulsion since the very beginning, and we are embarked on a program to understand the role of critical materials in these alloys containing cobalt, which are at the present time crucial to modern aircraft engines. What you see in Figure 10 on the upper lefthand corner is a depiction of the effect of taking cobalt out of one of these alloys. It is to reduce the rupture life. We are presently seeking a more detailed understanding of that, in addition to trying to think of ways to obtain the required properties without putting cobalt in.

A companion effort is directed at high performance ceramics, by which we mean ceramics which are capable of withstanding temperatures, such as we have in aircraft engines, and also exhibiting the strength and durability that is required by these engines. And the key to this is the processing of materials such as silicone carbide and silicone nitride.

We have made quite a bit of progress in this area through support from the Department of Energy funded automotive gas turbine program, and the turbine rotor which you see here is one made of silicone carbide. I just happen to have this rotor here; but be careful not to drop this, please, because we haven't solved all of the problems. The black rotor is of silicone carbide, the brown one is silicone nitride. These represent the state-of-the-art in ceramic materials for high temperature applications.

NASA initiated a General Aviation Aircraft crash program in 1972, with the objective of understanding general aviation crash dynamics, and it has developed quite a large library of data on the kind of phenomenon exhibited on Figure 12.

We feel it is very important to understand what happens in these crashes. We have been working at methods, also, to attenuate the loads that the passenger feels, and one of these is an impact absorbing structural concept for the floor of the aircraft, which cushions the seats in a crash. From these we hope to develop a modeling capability from which we can predict the behavior of an aircraft's structure in a crash, and a major emphasis in 1984 will be in that area. It will be coupled, then, with a validation through a full-scale transport crash. That is in calendar 1984.

Mr. GLICKMAN. When are you going to do that?

Dr. KERREBROCK. Calendar 1984. And that will happen at Dryden Flight Research Facility.

One element of the human factors program is to evaluate the benefits and limitations of cockpit displays of traffic information. The concept here is to give the pilot some of the information which

the air traffic controller presently has so that he can contribute to the implementation of proper separations for air traffic.

In 1982 the people at Ames developed a three-dimensional perspective display for the CDTI, which is shown on Figure 14 at the left. This is a cockpit display in which the pilot can see not only horizontal separations, but altitudes as well. Previous formats consisted of horizontal plan views, with the altitude displayed as just a number on the video, which is, of course, much more difficult to comprehend.

The preliminary tests indicate that this format enables the pilots to react much more quickly. We are going to evaluate this concept in the Man-Vehicle System Research Facility at Ames, which is the two-cockpit facility that I showed you, in 1984, and we hope then to go on to the evaluation of an advanced cockpit such as is shown here.

The very rapidly advancing state of computer science has many, many applications to aeronautics. We have focused our program on the three elements that are shown in Figure 15; of reliable computing, concurrent processing, and information management. Concurrent processing means processing data in parallel streams to speed up the execution. We are increasing the emphasis in that area in 1984, and it has very powerful applications in three ways, at least, to aeronautics, as exhibited here on the right. One is what we call fault tolerant computers, which are in the flight critical control systems of aircraft; therefore, we have to have very high reliability. The second is computational analysis, for example, in NAS, and third, interactive design.

As I mentioned, the Energy Efficient Engine program is planned for completion in 1983 (figure 18). During 1982, we got some very valuable results. The Pratt & Whitney high pressure warm air turbine rig and the General Electric high pressure compressor both exceeded the rig efficiency goals that we had established at the beginning of the program, and the turbine even exceeded the fully developed component goals.

This is probably a first in component development for aircraft engines, which has been in the past a very long and torturous process, and the fact that we could do it the first time reflects an increasing sophistication in the methodology, which will reduce the cost of future engines dramatically, I would predict.

We have evaluated the General Electric core. It exhibited excellent starting characteristics, good integrated component performance and an overall efficiency better than the program goal. In 1983 we are integrating that core with the low spool components and will evaluate the starting, transient, and performance capabilities.

The result of this program, which has been going on for several years now, is technology that reduces the fuel consumption of modern engines by about 15 percent. It is very close to the original goal of the program. Equally important is the fact that a good deal of this technology has already been incorporated in engines as the program went along, and it is flying in the 2037—that is a Pratt & Whitney engine—and in the General Electric CF6-80. So many of these technologies have already been transferred.

Mr. CARNEY. Are they engines that are sold to commercial——

Dr. KERREBROCK. Yes, sir.

Mr. CARNEY. They are not military?

Dr. KERREBROCK. No, they are commercial.

The 2037 is the engine for the Boeing 757, which looks to be one of the big production items. The CF6-80 will be used.

Dr. COLLADAY It is one of the engines that will power the Boeing 767.

Dr. KERREBROCK. The Advanced Turboprop program retains its potential for something like 15 to 20 percent less fuel consumption than for turbofan engines of the same technology generation. In the last few years we have made very significant progress in the area of installation aerodynamics where we have managed to eliminate a lot of interference drag, which people feared might be a problem. We have developed techniques for source noise predictions and methods for attenuating the noise through the fuselage of the aircraft.

In 1983 we will continue to progress in these areas, and also we will be able to implement several efforts including the detailed design of the large-scale prop fan, as exhibited on figure 19 by the finite element calculation, fabrication of an initial set of blades for laboratory testing shown schematically here to have a spar-shell construction. We will be able to fabricate and test two inlet models, one with a single inlet and the other with a bifurcated inlet. And we will also initiate preparation for a propeller test assembly consisting of an engine and gear box for a future flight research program.

This curious pair of devices in the upper righthand corner are a fatigue tester and a centrifugal hub whirl rig.

The funding that is available through 1983 maintains progress then, toward an early flight test of a large-scale propeller.

Mr. GLICKMAN. But your budget proposes terminating the work after 1983, does it not?

Dr. KERREBROCK. There is no line item in the budget. However, the work goes on through the period of fiscal year 1984, as I just mentioned, with the funding that is available.

Mr. GLICKMAN. How far will you be able to go with the prop fan, assuming we don't reinstate the moneys for the program?

Dr. KERREBROCK. These are the things I just mentioned, Mr. Chairman. We can back up to figure 19.

We will be able to do detail-design on the blades, fabricate a set of blades for lab test, fabricate and test these two inlet models, put together this propeller test assembly which is shown in yellow, and do some other important tests like this. The things that will remain to be done before a flight test can be launched are to construct the full-scale propeller for flight and prepare an airplane for flight.

Mr. GLICKMAN. Now, as I understand it, when you submitted your budget application to OMB, you had this included, didn't you?

Dr. KERREBROCK. Yes, sir.

Mr. GLICKMAN. And this was deleted by OMB; is that correct? At least you had $8.7 million submitted to OMB for advanced propulsion systems technology. Is that this thing we are talking about?

Dr. KERREBROCK. Yes.

Mr. GLICKMAN. And they deleted that?

Dr. KERREBROCK. It fell out in the prioritization of the program with OMB by the Agency.

Mr. GLICKMAN. All right. We will get to that later.

Dr. KERREBROCK. We continue to work on the technology of supersonic inlets and have brought the techniques for analysis of the behavior of these inlets to a very high state.

On the left of figure 16, is an inlet which is at an angle of attack with the computed flow field. That is a shock wave which is reflected there and there, for those of you who appreciate this sort of thing. The calculation has been carried through the three-dimensional viscous stage. We are now in the stage of experimental verification in the wind tunnel, with the rig shown.

Rotorcraft Technology programs have made many advances in the last year or two (figure 21). In the area of large transmission technology, we have developed finite element analysis techniques for large spiral bevel gears, which are a key technology for large rotorcraft. We have essentially proven the feasibility of the tilt rotor concept through the XV-15A aircraft, and many of you have seen that fly.

We have the two Rotor Systems Research aircraft which are research facilities operational now, one in the helicopter configuration and the other in the compound configuration with wings and booster engines. We have developed finite element techniques for modeling the vibrational behavior of helicopter fuselages. Those of you who have ridden in helicopters will recognize this as being a major problem. They shake themselves and their occupants quite vigorously and it is extremely important to be able to predict the vibrational frequencies and modes of these structures.

An augmentation for this year is technology for next generation rotorcraft, which covers two things (figure 24). One is continued work on the tilt rotor technology in the area of performance, aeropropulsion integration, and control behavior. Aerodynamic integration of the propeller with the fuselage and wing is what we mean by aero/propulsion integration. We are also looking at advanced configurations and the XV-15A will be used in flight support to corroborate any final configuration that might be selected for the JVX procurement by the Department of Defense. I should say that this is also a very promising configuration for commercial use, for example, for going to offshore oil rigs or any place where speed is very important. This vehicle has over a 300-knot cruise speed.

The second element in this augmentation is the cooperative program with DARPA to build an X-Wing, install it on the Rotor System Research Aircraft, and do flight research with it. The output of this will be rotor technology and the investigation of the feasibility of the stop/start conversion, which is very important. Perhaps I should explain that. This vehicle takes off in the helicopter mode with the rotor turning, and at about 250 knots, it would transition by stopping the rotor and flying as a fixed-wing aircraft.

The other augmentation is in the area of composite primary structures. Figure 26 shows the historical basis for this program. We have in the ACEE program developed the technology for secondary composite structures which are exemplified by the control

surfaces on the Boeing 737 aircraft. Here, it is only the movable part of the horizontal control surface.

The next step was medium primary structures, which are the vertical tail fins and the horizontal control surfaces on the larger aircraft. This happens to be a Lockheed 1011, and we are about to certify the vertical tail fin for the DC-10. We have also examined some critical design issues such as the notch sensitivity and impact damage behavior of these materials, their response to lightning strikes, and the effect of fuel.

The next step in this program is the augmentation for fiscal year 1984 which we call advanced composite structures technology and which addresses the use of composite materials in large primary structures of aircraft, where the largest payoff in terms of reduced weight and reduced manufacturing costs lies.

There are three elements to this augmentation (figure 27). One is developing the primary structures for fuselages, where the emphasis is on the behavior of the curved panels and what we call post-buckled loading behavior, meaning behavior after the structure crumples.

The second element is the large wing-box structure, that is the primary structural element in the wing, as indicated here. It carries the weight of the aircraft, and it also has the attachments for the landing gear, the flaps, the engine, and so forth. It is a very complicated and heavy structural item in a large airplane.

Finally, there is additional emphasis on better materials, tougher, higher strain composites, and more processable resin systems. For this program I might point out that although we are requesting $5 million in fiscal year 1984, it increases to $21 million in 1985, and the runout is $92 million.

One of the most important contributions we can make to the general aviation area is in improved stall/spin behavior of small aircraft, since spinning is one of the principal hazards of these vehicles. We have been attacking this problem vigorously at Langley. Figure 28 depicts the behavior of a normal airplane where, as the angle of attack increases, stall is reached and the lift then decreases with increased angle of attack. Now, they have evolved a configuration where the lift doesn't decrease but just moderates, as shown here, so that the behavior of the aircraft is much more predictable. We are also studying advanced configurations, some very futuristic ones such as are shown here.

We feel it is very important to lay a technological base for short takeoff and vertical landing aircraft, which is what the acronym STOVL implies.

Some of the elements that we have been working on are depicted in figure 30. First, configurations for a twin-engine fighter, then a single-engine fighter where there is an ejector type lift device imbedded in the wing. The little black spots indicate the air inlet region. There is a subscale ejector which has been under test indicated on the lefthand side. It is that kind of an ejector, but just a component test.

One of the most important problems in this area is simulating accurately the full aerodynamic behavior, which requires that the propulsion system be simulated in a small model. So we have devel-

oped a subscale propulsion simulator which takes the air in and blows it out in an exhaust jet so as to simulate a full-scale engine.

Finally, we have several very aggressive flight research programs in cooperation with the military services. In the upper left-hand corner of figure 31, we see the AFTI F-16 or advanced fighter technology integration F-16. Here the intent is to study advanced electronic control systems where the engine, the flight controls, and the munitions controls are all integrated. It even includes a voice-actuated control system so that the pilot can initiate actions of the airplane by enunciating key words. He only has two hands and two feet, and this is a very complicated vehicle, so the mouth helps.

In the upper righthand corner you see the mission adaptive wing research program depicted, which is conducted on an F-111, but it is really the wing we are focused on here which has a leading edge and a trailing edge which can be curled to change the camber of the wing so it can be adjusted for mission requirements.

At this point I would like to emphasize that the technology that comes from that will be as applicable to commercial aircraft as it is to military. The F-111 is a convenient vehicle on which to do the studies.

We are cooperating with DARPA in flying the forward swept wing aircraft shown in the lower left there to study the aeroelastic and aerodynamic behavior of this advanced configuration, which offers better transonic maneuverability and improved low-speed performance, as compared to the backward swept wing.

Finally, in the lower right you see what we call a decoupler pylon, which is a device for attaching external stores to a fighter aircraft without modifying the flutter behavior of the wings.

Now, in summary, I would like to say that I believe the program as highlighted—and these are only highlights; there is very much more—is responsive to the national aeronautical R&T policy and the views expressed by this committee. The fiscal year 1984 budget request builds positively on the momentum which has been generated with your support in the past, and with your continued support, I am certain we can effectively develop the technology required for U.S. civilian and military aircraft.

Mr. GLICKMAN. Thank you.

I am concerned that despite the upbeat tone of the policy statement by the Office of Science and Technology Policy, there are no funds in your request for prop fan, laminar flow control and the terminal control vehicle in 1984. These were all high priority civil technology programs that Congress supported in the strongest possible way last year. When I look at your budget, it seems to me that you are going up in military related areas, such as rotorcraft and high performance, but you are going down in nonmilitary related areas such as transport aircraft.

So I am asking you, are we refocusing this program to have more of a military orientation than we have ever had before, and, if so, is that bad or good?

Dr. KERREBROCK. Mr. Chairman, I would like to give you a generic answer first. Let me say that I think the answer is no, and then I will explain by repeating what I said earlier, which is that almost all of the work that you hear described here is of equal adaptabil-

ity a priority to military and civil aircraft. What we are doing is generating technological opportunities from which some application oriented organization, be it the military or a commercial organization, can then select concepts or technologies for application, which they can then carry on to full-scale engineering development and production.

The General Accounting Office in fact, in reviewing our program some months back, came to the conclusion that 95 percent of the work we carry on is of that category, jointly applicable. There are some elements which clearly have military application, and I would point to the decoupler pylon which I had in the lower right-hand corner of that last figure as one of those. We would not claim that that has civil applicability. It is, however, of extraordinary importance to the Tactical Air Force.

Mr. GLICKMAN. I am aware that your charter requires you to do military related research. I don't want to see a situation, though, where you are being used by DOD, with its very large budgets, to do things that they could otherwise be doing themselves. I just want to be sure that the projects you are doing are in fact the kind of things that do relate to civil technology as much as possible, and that you are not going beyond what the original intent of NASA was.

Dr. KERREBROCK. Yes, sir. I think we go to great pains to be sure that in the cooperative programs we conduct with DARPA and the Air Force and other agencies there is sufficient base R&T content to justify our participating.

Mr. GLICKMAN. Now, let me ask you this question in terms of some of the specific technologies. As to some of the initiatives that you presented to OMB that they did not approve, can you prioritize, let us say, the top three things that they did not approve?

Dr. KERREBROCK. In order, there would be the enhancement of the advanced turboprop program or a continuation of it in 1984; the funding for ATOPS [advanced transport operating system]. That is about $9 million.

Mr. GLICKMAN. How much was in the prop fan?

Dr. KERREBROCK. $8.7 million.

Mr. GLICKMAN. $8.7 million, all right. And you say it is $9 million for the ATOPS?

Dr. KERREBROCK. ATOPS.

Mr. GLICKMAN. That is the old——

Dr. KERREBROCK. The TCV program.

Mr. GLICKMAN. Yes.

Dr. KERREBROCK. But it is different. It is a continuation, not a new start.

Then there is laminar flow control. That is three.

Next would be the initiative on small engine component technology. And that was how much?

Dr. COLLADAY $4 million.

Dr. KERREBROCK. Yes, $4 million.

Then, the advanced turbofan research program which we had proposed as a follow-on to the energy-efficient engine program, which would address a next step advance in the component technologies for turbofan engines.

Finally there is the large rotorcraft technology program, which I happen to remember was $2 million.

Dr. COLLADAY Yes, $2 million.

Dr. KERREBROCK. I don't remember what the advanced turbofan research program was.

Dr. COLLADAY That was $5 million.

Dr. KERREBROCK. All right, $5 million.

Mr. GLICKMAN. Now, of all the technologies on which you either did or did not get approval from OMB to which do you think are ones that have the greatest implication for the long term?

Dr. KERREBROCK. Well, let me say, first of all, that we continually readjust and reprioritize our program within the R&T base so that we will somehow manage to do some work on those technical elements that we consider to be the most critical. Now, the pace at which we do it would not be what we would like and not what other people would like either, but we consider it our responsibility to be sure that the most important long-term opportunities, let's say, are addressed. I would like to say that I think that is extremely valuable. It gives the agency an opportunity to make sure that those things are covered. Beyond that, I would say that my priority order was essentially what I just gave you.

Mr. GLICKMAN. I assume, though, that you would perceive the NAS as being a project that would have long-term implications.

Dr. KERREBROCK. Oh, yes, sir. Perhaps I misunderstood you, because that is in the budget and that is the agency's highest priority in aeronautics.

Mr. GLICKMAN. Yes. I am going to turn the questioning over to Mr. Carney, but first I would like to tell you as well as the rest of the subcommittee that the American Institute of Aeronautics and Astronautics has analyzed the NASA program. They have prepared a program for us which I think my staff has given you just in the last few minutes or before the hearing. They make some recommendations on NASA's program which I am going to share with all the members of the subcommittee.

We asked them to do this in a helpful way, and I think they came up with some instructive suggestions. If you have any comment on their report, I would be pleased if you would share it with us.

Dr. KERREBROCK. I certainly will.

Mr. GLICKMAN. Mr. Carney?

Mr. CARNEY. Thank you, Mr. Chairman.

Along the lines of the questioning of the chairman, if you had that hypothetical ability to come right here and not go through OMB, would you take those half-dozen items and divide them equally between Wichita and Long Island?

In a serious vein, we had hearings last December on aeronautics research, and General Schriever and Dr. Augustine of AIAA appeared before this subcommittee. Both brought out the fact that there haven't been many experimental research aircraft coming along the line. Years ago you would bring out 15 or 16 aircraft, and today we have one or two at best. They both felt that we should go back to more experimental-type aircraft.

I was wondering what your views are on that, and would you support that? In fact, Dr. Augustine suggested that we should be

building at least three new experimental type aircraft a year. I was wondering what your feelings are on that.

Dr. KERREBROCK. Well, I think that there is a very important role for experimental aircraft in addressing wholly new configurations where there is a whole complex of new concepts that are being incorporated and where the viability of the concept itself is a critical issue.

I think I would dispute the statement, though, that there haven't been very many of these. I showed you some of those here. The X-wing is exactly that; the tilt rotor is that; the X-29 forward swept wing is an experimental aircraft.

Mr. CARNEY. That is three, and they have been around as long as I have been in the Congress, which is 4 years.

Dr. KERREBROCK. Yes, sir, but we are just getting ready to fly the X-29 now, and the tilt rotor is still in the research phase. I wouldn't say that there are not further concepts that need to be explored. In fact, there is another one I could mention, which is the oblique wing concept which NASA has explored on a low budget level. I am referring to the one with a scissors wing.

Mr. CARNEY. Yes, sir.

Dr. KERREBROCK. I really do think at some point it would be advisable to go on to the next step of examining the high-speed characteristics of that configuration. However, that I don't think we need to build experimental aircraft for next generation transports. I think we have advanced to the stage where one can, through the sophisticated design tools, wind tunnel testing, computational fluid mechanics, and so forth, go on to the next generation transport without building an experimental aircraft. And these aircraft are extremely expensive, so that is a big step forward.

I don't know whether that answers your question or not.

Mr. CARNEY. Well, it is telling me your thoughts on the issue, yes.

Mr. GLICKMAN. Will the gentleman yield on that question?

Mr. CARNEY. I yield to the chairman.

Mr. GLICKMAN. Have you ever thought of building a fully composite airplane?

Dr. KERREBROCK. Yes, sir. But we think it makes more sense to proceed the way we are, which is to build the major components and the limiting components and to examine their behavior instead of building a whole airplane since a lot of the airplane is not critical. The critical ones are the main spar for the wing and the curved panels for the fuselage.

Mr. CARNEY. Do we find ourselves under those circumstances getting into an evolutionary mode as opposed to a revolutionary mode in research and technology?

Dr. KERREBROCK. No, sir; I don't think so. In a real sense, the changes that are happening now in transport aircraft are revoutionary. The performance of the 767 is so much better than the 707 that it is a revolution. It looks the same, but it isn't the same.

Mr. CARNEY. Yes. I am not an engineer, but if you were to tell me that is revolutionary after looking at that thing, I would be wondering why you are running the agency or be in your position. Of course, I am acting from ignorance. That, to me as a novice or just a "Joe" who goes to the airport and gets on one and asks a

stewardess, "What kind of plane is it?" would be more evolutionary. You are talking about performance increases, fuel savings increases, and that type of thing on a plane that is virtually the same. I mean there is no real change that I could see that would be of a revolutionary nature.

Dr. KERREBROCK. I realize that. That is why I made the statement I did. The changes are underneath the surface. They are in the aerodynamics, in the structure, in the engine, and so forth. I would venture to say that by some measure there is a factor of 2 difference between the two aircraft.

Mr. CARNEY. If there is a factor of 2 between those, what would you say the factor would be between an all-composite aircraft, for instance, that the chairman was talking about or a hypersonic research aircraft? What would the factor be there?

Dr. KERREBROCK. Those are different situations. An all-composite aircraft would not at this time be cost-effective, and that is because the incorporation of composites in many of the components would be more costly, both in terms of first cost and life cycle cost than the metal structure.

Boeing, McDonnell-Douglas, and Lockheed are systematically incorporating composite components in the new aircraft as soon as it makes sense. What was on charts that I showed you was that incorporation—first in the control surfaces and in larger and larger components. Eventually, there will be aircraft in which the primary structure, which is where the main weight of the airplane is, will be made of composites.

Mr. CARNEY. Let me as a layman make a comparison, then, with something like the forward swept wing. That to me is, from what I see, something that would be more revolutionary than evolutionary, as opposed to the changes that I see in the aircraft you are talking about.

Dr. KERREBROCK. One has to distinguish between the appearance and the reality. In fact, it may be that the performance gained from the forward swept wing is considerably less than the performance gained from the integrated control system which is going into the F-16. Do you see what I mean?

Mr. CARNEY. Yes.

Dr. KERREBROCK. Which is not apparent to the casual observer at all.

Mr. CARNEY. I understand what you are saying.

Dr. KERREBROCK. One of the things that is coming along certainly in some future generation of transport aircraft will be what we call control configuration, which means that you decrease the size of the tail, for example, of the airplane and you stabilize the airplane electronically. Now, the casual observer looking at it would say, "Gee, that thing has a small tail, but that's not a revolutionary change." But it really is, because that is an airplane in which, if you snip the wires, it will fall to the ground. It requires a revolutionary change in the art of electronic controls toward a much higher reliability.

We are working on that very hard, and there are very large gains to be gotten from that kind of change.

Mr. CARNEY. Mr. Chairman, I think I have pursued this question enough, and the doctor has proven to me he can certainly dance.

Dr. KERREBROCK. That wasn't what I was trying to prove.

Mr. CARNEY. I will yield back the balance of the "tune."

Mr. GLICKMAN. Mr. Boehlert.

Mr. BOEHLERT Mr. Chairman, I knew when I came here, that I didn't know all the answers. I am not sure I know any of the questions. I am still trying to get over "gigaflops."

I have no questions, Mr. Chairman.

Mr. GLICKMAN. Mr. McCandless?

Mr. MCCANDLESS. Yes, Mr. Chairman.

I want to clarify this point because to me it is important. Do I understand that under the subsonic aircraft systems technology in budget 534, 01 to 06, these were recommended for funding, but that they were some of the things that were deleted before you arrived at this point?

Dr. KERREBROCK. Yes, sir. They are items that fell out in the prioritization process.

Mr. MCCANDLESS. Laminary flow control, from the little I know as a reformed used-car salesman turned politician, is a very important part of being able to develop efficiency; that is reduce drag, and improve fuel economy and performance.

Have you reached a point in that particular program where further research is minimal, I mean the benefit per dollar is minimal?

Dr. KERREBROCK. No, sir, the laminary flow control situation is really quite the opposite. What we are trying to do is to assess or establish the feasibility of causing the flow over the wings to be laminar instead of turbulent. If you can do that to a significant extent on an airplane, then the drag of the airplane goes down by a large factor. The question is not does the drag go down if you make the flow laminar, but, can you design a configuration for the airplane in which it is practical to control the airflow and make it laminar? The stage we are in now is one of assessing some conceptual ways for doing that.

I could describe one for you which is to use a leading edge on the wing which has a very large number of small holes in it through which you pull air. You suck, in other words, and the suction stabilizes the boundary layer, and then that influences the flow over the whole rest of the wing. This program was intended to design and then install such leading edge flight test components on the NASA Jetstar aircraft that we have out at Ames and then fly them to assess their behavior in actual flight conditions. That is a very important part of it because one of the problems with laminar flow control is that any contamination by insects or dirt of this very fine structure tends to impede the laminarization process.

Mr. MCCANDLESS. At the point of going into a basic school text, if I remember it correctly, the difference between a round-headed rivet and a countersunk rivet was to create what it is you are talking about in the construction of an aircraft wing or fuselage?

Dr. KERREBROCK. Yes, except that in both you have turbulent flow, so that was just to reduce the drag. But even with the flat-headed flush rivets, you still have turbulent flow. Now, this is to take a further step and cause the flow to be laminar, in other words, smooth, steady, instead of fluctuating.

I want to make sure that I leave you with the right impression. The laminar flow control concept really offers a very large improvement in aircraft cruise performance.

Mr. McCANDLESS. The thing I am really trying to get at is that the fuel efficiency of our commercial aircraft is what will sell them as a nation on an international trade basis, and if we have a little bigger bag of tricks in our final product than our competitors, who are beginning to get a commercial edge, it would appear to me that they would be more salable and more desirable and we can make more of them and have more employment and all the other good things.

That is why I was concerned about the laminar flow program being dropped, because it appears to me that is one of the things you might be able to excel at in the next generation.

Dr. KERREBROCK. It is one, yes.

Mr. McCANDLESS. It would seem to me that another area in that same category is advanced control systems and what they might be able to provide in the way of improved transport operating systems. Isn't that also a technology that if taken out to its ultimate end would give us a sales edge on our competitors in the commercial market?

Dr. KERREBROCK. Yes, sir, it is. We are exploring that in the fiscal year 1983 program, in the energy efficient transport program.

Mr. McCANDLESS. I guess what I am trying to build on is our chairman's discussion about the commercial and military application of the programs that you have, and the importance of our continuing to build commercial aircraft, and that it would appear in some cases, important areas are not going to be addressed as they have been in the past.

Dr. KERREBROCK. I would like to say again what I said a little bit earlier, that some of these areas are of such crucial importance that we will assign sufficient priority to them to address them at some level within the resources that are available to us. We consider that our responsibility. It is a question of pace rather than actual deletion.

Mr. McCANDLESS. One of these hearings developed the information that approximately 50 percent of the wide-bodied aircraft now being sold in the world are being sold by foreign manufacturers. If that is a correct assessment, are these aircraft a result of better technology or development, more research, or is there a third factor of merchandizing, for example subsidies, or something of that nature?

Dr. KERREBROCK. No, sir. What you are referring to—well, leave out the "no." Let me see if I can explain it.

What they are referring to is incursions that Airbus Industries has made into the large air transport market which was before that held almost entirely by U.S. manufacturers. The technology of the A-300 and the A-310 is not superior to the technology of the U.S. aircraft that compete with it. The A-300 was designed, built, and put into production at a time when it happened to meet a market need for a large twin-engine transport.

So it supplied a segment of the market which we did not meet with our tri-jets, the Lockheed 1011 and the DC-10. That in part accounts for its success on the market.

Another aspect of it is the favorable financing arrangement which the European countries have offered in order to market these aircraft. In addition there is probably a tendency for some segments of the market to prefer European aircraft to U.S. aircraft, that is, European airlines, so that the combination of these things opened up a very large market segment for the airbus industry, which they have very skillfully exploited.

Mr. MCCANDLESS. Thank you.

Mr. GLICKMAN. Mr. Andrews.

Mr. ANDREWS. No questions.

Mr. GLICKMAN. Dr. Kerrebrock, I want to ask you a question in reference to that accident at the Ames Research Center. When can we expect a report of your investigation on the wind tunnel accident?

Dr. KERREBROCK. I am supposed to receive a briefing on that the 15 of this month and then we will brief it to Mr. Beggs on March 2. As soon as we have an OK from him, we will explain it to you. Will that be satisfactory?

Mr. GLICKMAN. Since you are going to be remaining at a fairly level work force, I assume you are going to be hiring some people.

Dr. KERREBROCK. Yes, sir.

Mr. GLICKMAN. Do you expect to have any problems attracting people from the aeronautical sciences?

Dr. KERREBROCK. No. The present indication is that there are very many talented young people out there who would like to work for NASA. The situation is better than it has been for some years, so we regard that as a real opportunity.

Mr. GLICKMAN. How many young people do you expect to hire in the next fiscal year?

Dr. KERREBROCK. We call them freshouts.

Mr. GLICKMAN. OK, freshouts.

Dr. KERREBROCK. About 300 in the 3 research centers, which is almost 10 percent.

Mr. GLICKMAN. How many will you hire this fiscal year?

Dr. KERREBROCK. We don't know yet. The hiring is going on right now. There is a lot of action. We have a lot of offers out there and a lot of acceptances. It looks very good, but I can't give you a number right now. I could give you that for the record if you would like.

Mr. GLICKMAN. I would like that if possible.

[The committee insert follows:]

In light of the current favorable hiring climate and the high numbers of new graduates in the disciplines of interest to NASA, we believe we have a unique opportunity to bring a significant number of new people into the NASA work force. So for this fiscal year, the three OAST Centers have extended 370 offers to newly graduated scientists and engineers with B.S., M.S., or Ph. D. degrees. The prospects for attracting high-quality graduates is excellent because competition from the private sector is less than normal as a result of current economic conditions. Based on current trends we anticipate an acceptance rate of our offers which would result in the OAST Centers hiring approximately 250 during fiscal year 1983.

Mr. GLICKMAN. One of the things we are considering in the full committee and in the full House, there is a variety of science-math-

education related programs, so the number of people who are going to work at NASA in the aeronautical sciences would be useful to us.

Can you think of any programs that you provide funds for that substantially duplicate what industry is doing and should be discontinued?

Dr. KERREBROCK. No, sir. If we could, we would discontinue them.

Mr. GLICKMAN. Well, I have heard some thoughts that the IPAD program, integrated program for aerospace design duplicates what industry is doing.

Dr. KERREBROCK. That is really very, very wrong. As a matter of fact, the IPAD program has more support from the industry per dollar of funding than any program I have seen since I have been in Washington. It is very modestly funded, I think $2 million a year.

I attended a meeting last year where there must have been two dozen high-level representatives from the aeronautical industry trying to convince me to continue that program because it is so crucial to them. It is a very valuable program, I am sure.

Mr. GLICKMAN. I want to ask a final question, if possible.

The delineation of functions within the R&T base has always been one that has been a bit nebulous to me. That is, you talk in general about the descriptions of programs in your statement and in your view graphs and it is fairly easy to define those programs and systems technology that you are working on. One of the suggestions I think you will find from the AIAA is that perhaps there needs to be more careful review of what is going on in the R&T base to insure that it does not just become a continuation of what has been happening in the past, and also that they may not get enough focus in terms of delineation of specific goals.

I wonder if you might speak to that.

Dr. KERREBROCK. Yes, I would be happy to.

First of all, we look at it continually and reprioritize it continually to be sure that there are not ongoing activities that just continue because of momentum. There is so much pressure for support of new innovative ideas and thrusts as we call them that it would be very hard to have a stagnant pocket of funding without somebody discovering it, so I have some confidence that that is not a problem.

If you divide the total R&D funding of the $300 million, into two categories, one of disciplinary research which supports the basic fluid mechanics structures and the other category of systems research, which I characterized earlier, the systems research is about 60 percent of the total. In other words, 60 percent of the money is focused on the interaction between components of the system or proof of concept or things like that and 40 percent is disciplinary. That is quite different from the subdivision between the R&T base and the systems technology programs, which are the funding categories.

I am trying to indicate that in the R&T base that there is a lot of systems research.

Mr. GLICKMAN. Well, for example, in the area of icing, I assume a lot of the icing work would be categorized as systems related.

Dr. KERREBROCK. Yes, sir; that is all carried in the R&T base.

Mr. GLICKMAN. One of the areas that we perhaps have not reviewed as carefully as we should in terms of the oversight process is the R&T base, because the systems technology items tend to jump out and relate to specific things like energy efficiency and they tend to generate the institutional support.

Dr. KERREBROCK. Well, I would like to say that they are equally important.

Mr. GLICKMAN. It is more difficult for us in the budget process to see ultimate applications in the R&T base than it is in the systems technology programs and what you have just told me is that a lot of the R&T base has that kind of orientation to it.

Dr. KERREBROCK. Yes, sir. I would assert that there is very little, if any, activity in the NASA aeronautics program which is not well motivated by some eventual application. There are questions of time scale, whether the application comes in 5 years, 10 years, 15 years, or 20 years. That is really the difference between the different kinds of activities.

On the other hand, it very often happens that some activity you are engaged in essentially in the pursuit of knowledge turns out to have an immediate application. So it is very difficult to set up these boundaries.

Mr. GLICKMAN. Do you personally feel that the change in the OSTP aeronautics policy is being implemented in this budget in terms of the reaffirmation by the Government toward aeronautical research and development? Do you think this budget reflects a dramatic change from what we heard last year and the year before in terms of aeronautical policy?

Dr. KERREBROCK. You know, drama is in the eyes of the beholder, but I think it is a very constructive change from last year; yes, sir.

Mr. GLICKMAN. OK, we thank you.

Does anybody else have any questions or thoughts?

We thank you for coming down here.

We have no more program review hearings on NASA or the aeronautics budget. The next meeting will be February 23 at 2 p.m in this room on the Department of Energy transportation budget. We will mark up these budgets on March 3, so we will be talking to you before then.

Dr. KERREBROCK. Thank you.

Mr. GLICKMAN. The hearing is adjourned.

[Whereupon, at 3:45 p.m., the subcommittee recessed, to reconvene at 2 p.m., Wednesday, February 23, 1983.]

[The prepared statement of Dr. Kerrebrock follows:]

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PRESENTED BY WITNESS
FEBRUARY 9, 1983

Statement
of
Dr. Jack L. Kerrebrock
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Transportation, Aviation
and Materials
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to present to you today the FY 1984 Aeronautical Research and Technology (R&T) budget request. I believe that the proposed program should largely meet your desires for a strong effort in both disciplinary and systems activities, balanced between use of NASA's in-house capabilities and the R&T talents of industry and academia. Together with a vigorous Construction of Facilities, CofF, program to which I will allude briefly, this program should enable NASA to maintain and enhance the already outstanding aeronautical R&T capability represented by the Ames, Langley, and Lewis Research Centers.

This submission reflects an improved consensus on the role and scope of federally funded aeronautical R&T arrived at in hearings conducted by the Congress, and in a broadly-based study conducted by the Office of Science and Technology Policy (OSTP), which recently culminated in the expression of a National Aeronautical R&T Policy. I wish to spend a few moments reviewing the high points of this policy, before proceeding to a description of the program.

The OSTP report recognizes that military and civil aeronautics, and the long-term health of the aeronautical manufacturing industries, are matters of important national interest. It further points out that continued strong aeronautical R&T advancement can be expected to produce large gains in aircraft performance, and therefore is essential for national security and for continued success of

the U.S. civil aeronautics industry.

The report recognizes that aeronautical research and technology development activities in support of future military and civil applications are largely common. It reaffirms that continuing government support of aeronautical research and technology development is necessary to the success of our civil aeronautical industry because private aeronautical companies have limited incentive to invest in long-lead future-oriented research due to their inability to effectively capture the benefits of such investment.

The OSTP report recommends continuation of the present R&T organization, in which NASA funds, directs, and implements aeronautical research and technology development programs, has prime responsibility for maintenance and operation of the nation's key aeronautical research facilities, supports military aeronautical technology demonstrations, and conducts aeronautical R&T related to safety and air traffic control.

The Office of Aeronautics and Space Technology (OAST), in collaboration with the Research Centers, has prepared an Aeronautics Long Range Plan which is fully consistent with the OSTP and Congressional recommendations. Primary emphasis is placed on: disciplinary research directed at improved understanding and new concepts in the major aeronautical technical disciplines; systems research on the interactions among system components and on the technologies uniquely related to the various classes of aircraft; and proof-of-concept investigations to establish feasibility of promising technical advances. These activities all lie within the OSTP category of research and technology development, and are directed at technology advances applicable to both civil and military future needs.

Our Long Range Plan is structured around four key objectives:

- Maintain excellence in Research Center capabilities.

- Strengthen NASA/university partnership to ensure full participation by the academic community.

- Strengthen industrial participation in the NASA program.

- Maintain a balanced aeronautics program

consisting of disciplinary research, systems research, and selected proof-of-concept activities with emphasis on common applicability to both civil and military aviation.

Before turning to the proposed FY 1984 program, let me briefly discuss our plans for the Institution which plays such a key role in the aeronautics program. The aeronautical facilities and capabilities of the Research Centers represent a significant national investment. Our plans to protect this investment include a multi-year repair and replacement program, a Facility Productivity Improvement Program to enhance the utility of existing facilities by increasing test efficiency, and continuing enhancement of the computational capabilities.

At the Ames Research Center, the Man-Vehicle Systems Research Facility, shown in Figure 1, will begin operation later this year and will provide for full-mission simulation of multiple aircraft, crew interaction with air traffic control, and conventional and advanced cabs. A new Data Analysis Facility, which will increase the Dryden Flight Research Facility's automatic data processing capabilities is nearing completion. The modifications to the 40X80-Foot Wind Tunnel, which will provide a higher speed test capability and an additional 80X120-foot test section, have unfortunately been delayed about 2 years, as a result of a turning vane failure and subsequent fan damage that occurred during checkout testing. We will be taking all possible steps to expedite satisfactory completion of this important facility, which was originally scheduled to be available during FY 1983. In the FY 1984 CofF budget request, we include for Ames Research Center a Fluid Mechanics Laboratory for investigation of turbulence, separated flows, and shock-boundary layer interactions, and an expansion of the Dryden multi-frequency tracking and data acquisition capabilities.

New facility developments recently or soon to be completed at the Langley Research Center include the National Transonic Facility and the Avionics Integration Research Laboratory, both shown in Figure 1, and modifications to increase the productivity and test capability of the 4X7-Meter Low-Speed Tunnel and the Transonic Dynamics Tunnel. The latter is not only a national resource for aeroelasticity research on high speed aircraft, but has also been employed in important flutter and

buffet investigations on the Shuttle and other space and launch vehicles. For FY 1984 at Langley Research Center, we are requesting CofF funding to modify the 50-year old, but still uniquely capable, 30X60-Foot Wind Tunnel to improve its productivity, efficiency, and model support systems, and to modify and expand the Composite Materials Laboratory for more effective research on improved composites for advanced aircraft and large space structures.

At the Lewis Research Center, the controls and airflow of the central air system, which provides high pressure air to the propulsion facilities, are being upgraded to double the current air capacity supplied for advanced engine research. Our FY 1984 CofF request for Lewis Research Center will enable an upgrading of several test cells for research on small turbine engine components, and a modification of the 37-year old Icing Research Tunnel to improve its productivity and efficiency.

The centerpiece of our proposed aeronautics program for FY 1984 is the new Numerical Aerodynamic Simulation (NAS) capability, which will be developed over the course of the next few years. The NAS capability will include a large computer system which will make it possible to perform most of the calculations required to design a new aircraft with sufficient accuracy and reliability to significantly reduce the long and expensive process of wind tunnel and flight testing now necessary. There is every reason to believe that the computer technology to achieve this objective can be developed in the next few years, and there is no question that the capability the NAS represents will make it possible to design new airplanes and engines much more effectively. The investment made in NAS will provide incentives for various elements of the computer industry to produce machines which will be able to take advantage of major commercial applications. Developments of this kind will enhance the competitive posture of the United States in this important international market.

The FY 1984 Research and Development (R&D) budget request is shown in Figure 2 and compared with the FY 1982 and FY 1983 budgets. The total request for FY 1984, which is fully consistent with the Aeronautics Long Range Plan, is $300.3 million, of which $227.8 million is for the Research and Technology Base and $72.5 million for Systems Technology. We are also proposing essentially the same number of civil service positions in FY 1984 as in the FY 1983 budget. The resources to provide this continuing level of support are included in the

Agency's FY 1984 Resources and Program Management (R&PM) budget request. A breakdown of the total Aeronautics budget request is shown in Figure 3, along with the R&D split by Center.

The importance of the industry and the universities as direct participants in the aeronautical R&T programs is illustrated in Figure 4, which shows their portions of the effort relative to the in-house NASA activity. Existing mechanisms for university participation, such as grants, contracts, and faculty involvement in advisory committees, are augmented by several institutes, which are jointly operated by NASA Centers and universities in computer applications, flight sciences, and aerospace propulsion and power. New activities include the proposed Research Institute in Advanced Computer Science (RIACS) at the Ames Research Center, which will be similar to the existing Institute for Computer Applications in Science and Engineering (ICASE) at the Langley Research Center. In addition, two new centers of excellence in computer science and its aerospace applications were established for the dual purpose of focusing academic computer science expertise on critical aerospace applications and on fostering a new generation of aerospace engineers highly proficient in computer technology.

We continue to coordinate closely with U.S. industry and the Department of Defense (DOD), our user community, in the planning and execution of our aeronautical R&T programs, and in improving the effectiveness with which NASA technology advances are translated into advanced vehicle design and development. We are striving to strengthen these relationships, and in this regard, we are paying particular attention to the OSTP recommendations relative to early effective dissemination of technology within the U.S. community prior to unrestrained widespread dissemination and to acquiring, assimilating, and disseminating unclassified technology information available from non-United States sources.

We maintain equally close relationships with the Federal Aviation Administration (FAA), with effective mechanisms for formal and informal coordination at all levels. During this past year, the Administrators of NASA and FAA have agreed on a number of areas in which increased R&T emphasis by NASA could lead to further improvements in air safety and air system efficiency. This agreement is reflected in our FY 1984 planning.

OAST has recently been assigned the responsibility for managing NASA's Small Business Innovation Research (SBIR) Program in accordance with the Small Business Development Act of 1982 (PL 97-219). We are currently working toward release of the first solicitation for proposals in the spring. Although this effort will cover the entire range of NASA interests, we look forward to this opportunity to add to our industrial aeronautics team a number of small creative groups offering fresh ideas and approaches.

Our main purpose today is to outline the FY 1984 programs we are proposing as the next step toward meeting the primary objective of maintaining an aeronautics program which effectively encompasses the full technology development spectrum from fundamental disciplinary advancement through systems research and proof-of-concept investigations. I would now like to address selected high priority goals in each of these areas, discussing recent accomplishments, FY 1984 plans, and long range objectives.

FLUID AND THERMAL PHYSICS - The objectives of the fluid and thermal physics research and technology program are: to advance the speed and scope of computations for the prediction of fluid dynamic flow over aircraft and in turbomachinery; develop practical means to improve the aerodynamic efficiency and environmental acceptability of aircraft and propulsion systems; and provide the experimental technology required for precise aerodynamic testing.

Construction of the National Transonic Facility (NTF) was completed in FY 1982, and a comprehensive operational checkout is in progress. Concurrently, equipment and models are being constructed for a thorough calibration of facility flow quality, and test techniques and instrumentation peculiar to cryogenic operating conditions are being developed. An extensive data correlation program will provide comparisons of flight and other transonic wind tunnel test results with the NTF data. As illustrated in Figure 5, the correlation program includes FY 1983 tests of the NTF Pathfinder I transport model. In FY 1984, tests will include a Boeing 767 transport model, the Pathfinder II fighter model, and a Shuttle Orbiter model. Both of the Pathfinder models are constructed of modular components, providing easily modified transport and fighter configurations. The aircraft industry will use these models for evaluating specific component design variations at the previously unattainable

high Reynolds number test conditions of the NTF.

The computational fluid dynamics (CFD) program addresses the problem of calculating aerodynamic forces, torques, and oscillations imposed on the external components of aircraft, as well as, the internal ducts, rotating blades, and stators of engines and jet nozzles. An example of the development of reliable analytical techniques for predicting external flow over engine afterbodies is illustrated in Figure 6. Currently available methods do not couple the external and exhaust jet flows and, therefore, cannot adequately model the base flow region. New computational methods are being developed to solve the Navier-Stokes equations through a fully coupled flow region, accurately simulating the interaction of the two flows. Good agreement between a recent code validation result and experimental data is shown on the left of the figure. This computational development is a result of a joint Army, Navy, NASA, and Air Force effort to coordinate the development of exhaust plume technology. In FY 1984, the two-dimensional code will be improved by more complete physical modeling and higher computational resolution of the flow field. This improved code, which will be extended to three dimensions and validated by wind tunnel tests, will be used to predict afterbody flows. This will lead to reduced engine installation drag for improved commercial aircraft efficiency and military aircraft performance.

An important objective in CFD for internal flows is to develop the capability to optimize turbomachinery blade designs. Current empirical methods, which are costly and time consuming, are nearing their limits for improving performance of fans, compressors, and turbines. Consequently, Lewis Research Center, working with DOD, universities, and private industry, is emphasizing the development of advanced internal flow codes and is demonstrating advances in code application to fan, compressor, and turbine technology. Illustrated on the left of Figure 7 is a recent evaluation of a Navier-Stokes code showing good agreement between predicted and experimental data for a typical transonic stator blade. This two-dimensional code will be extended in FY 1984 to include three-dimensional viscous effects. This new technique will provide the gas turbine industry with a more accurate design tool for blade shape analysis, and will lead to improved engine fuel efficiency and performance range.

To pace the rapid advancement in CFD, NASA proposes to maintain the leading edge in scientific

computation through the Numerical Aerodynamic Simulation (NAS) program. This will be a continuing effort to provide the nation with the world's fastest and most powerful analytical facilities. The system will enable a large number of users from NASA, academia, industry, and other government agencies to solve previously intractable problems in aeronautical design. Specifically, it will play a major role in maintaining U.S. leadership in the development of fuel-efficient engines and low-drag aircraft by solving the three-dimensional fluid equations that govern the aerodynamic flow through turbomachinery components and over complex aircraft and missile configurations. Numerical Aerodynamic Simulation will also provide similar benefits for other computationally oriented disciplines, such as chemistry, structures, and weather prediction.

The NAS system, as depicted in Figure 8, will be assembled from prototype and commercial equipment for initial operation in FY 1985. The key features will include a high speed processor, graphics stations where users can quickly visualize the physical processes they are simulating, multiple work stations, satellite and telecommunications interface links to remote users, a large data base mass store, and a high speed network tying these elements together. The high speed processor, the key to maintaining a computational leading edge, will be updated regularly to ensure that it is the fastest prototype scientific supercomputer available.

Figure 9 illustrates the impact of evolving processor speed and memory on the scope of fluid flow simulations for a 15-minute calculation of the Navier-Stokes equations. As noted on the lower left of the figure, the CDC 7600 (a mainstay computer of the 1960's and early 1970's) could provide only restricted solutions, such as those for a two-dimensional transonic airfoil. More recent Class VI machines, such as the Cray 1S or Cyber 205, permit three-dimensional solutions of simple inclined bodies, such as aircraft boattails. The initial NAS system will compute solutions for three-dimensional wings with flaps, and by 1987, NAS will be used to simulate complete aircraft shapes including the fuselage, wings, nacelles, engines, and tail.

MATERIALS AND STRUCTURES - The objectives of the materials and structures research and technology program are: to characterize advanced metallic, ceramic, polymer, and composite materials; develop structural concepts and design methods to exploit

the use of advanced materials in aircraft; and improve analytical and experimental methods for determining the behavior of aircraft structures in flight environments.

The availability of hot section component materials and improvements in fabrication processes for gas turbines are critical technologies for enhanced performance and durability, and reduced parts-cost for future U.S. aircraft engines. The Lewis Research Center has as one long range goal the reduction of the need for strategic elements, such as cobalt, tantalum, columbium, and chromium, in gas turbine engine materials. The activity is directed toward determining the effect that these key strategic elements have on the properties of nickel-base superalloys. Emphasis is placed on physical metallurgy and advanced processing concepts. Recent research on cobalt demonstrated the effect of alloy content on rupture life, as illustrated in Figure 10. Understanding of the strengthening mechanisms involved is expected to lead to possible strategic element substitutes. Additionally the increased understanding of the response of nickel-base superalloy phase distribution and substructure to processing variables gained in this program will provide a further basis for improving the properties of, not only reduced strategic element content alloys, but also the high temperature alloys of the future.

Ceramics, which contain no strategic materials, offer the potential advantages of higher temperature strength, lower density, lower cost, and greater corrosion resistance. However, the wide variation in current ceramic material properties reduces their usable strength. Lewis Research Center investigators have recently achieved a fourfold increase in the strength of silicon nitride in the 2500-degree Fahrenheit range, as shown in Figure 10, by using a new process of very high nitrogen pressure sintering of the ceramic powder. In FY 1984, the effects of starting powders and processing variables on the resulting material characteristics will be investigated. Further advancement in life prediction and non-destructive evaluation techniques will lead to assessments of ceramic component service and enhance the potential for industrial application.

Eliminating or minimizing aeroelastic effects such as flutter and buffet can provide significant improvements in aircraft performance, ride quality, and service life. Several wing configurations were recently tested in the Transonic Dynamics Tunnel at

Langley Research Center to obtain pressure measurements and establish flutter boundaries. As shown in Figure 11, tests of a rectangular supercritical wing at small angles of attack showed good correlation with predictions of a two-dimensional aeroelastic code. In FY 1984, this code will be extended both to account for flutter boundary changes at higher angles of attack and to incorporate three-dimensional aerodynamics and viscous flow effects. This research will provide the realistic computational models of advanced wing configuration aeroelastic response to transonic flow, needed for the design of future aircraft.

Analytical models of dynamic impact response provide the critical information needed for aircraft crashworthiness design criteria. NASA's general aviation crash dynamics program, which began at Langley Research Center in 1972, has focused on developing analytical nonlinear crash impact models, on validating those models through full-scale testing, and on developing load-limiting subfloor and seat structural concepts, as shown in Figure 12. In FY 1982, the load attenuation capability of various crushable subfloor designs was statically and dynamically tested. A predicted 35 percent reduction in crash deceleration was verified. The analytical modeling capability provided a basis for beginning the development of nonlinear crash dynamics analysis methods for large transport aircraft. NASA working closely with the FAA and industry has developed a crash scenario for a full-scale remotely piloted transport aircraft crash test at the Dryden Flight Research Facility in FY 1984. Special on-board instrumentation and data systems have been developed to acquire crash data which will be used to validate analytical prediction models.

CONTROLS AND GUIDANCE - The objectives of the aircraft controls and guidance program are: to develop architectures for flight-crucial systems for future aircraft; to devise analytical methods and test techniques for assessing the reliability and performance of complex integrated fault tolerant flight control systems; and to develop mathematical control laws and design methods for extending the performance envelope and reliability of future civil and military aircraft.

The development of technology for highly reliable, flight-crucial electronic control systems is an important step in expanding the options for design of lighter weight, more fuel efficient, and higher performance aircraft. By the late 1970's, the

highest level of electronic control system reliability that could be reached was only about one failure per million flight hours, as illustrated in Figure 13. However, industry has identified one failure per billion flight hours as the design goal for commercial aircraft flight-crucial electronic control systems. The Langley Research Center, in cooperation with academia and industry, has pursued a research program to develop new systems concepts with the desired level of reliability. As a result of this research, engineering models of two pioneering computers called SIFT, for Software Implemented Fault Tolerance, and FTMP, for Fault Tolerant Multiprocessor, were completed in FY 1982. These computers were designed to achieve the desired reliability levels by using advanced system and software architectures capable of detecting failures and reconfiguring themselves for continuous operation.

Initial evaluation of the Fault Tolerant Multiprocessor began at Draper Laboratories in 1982 with a series of fault injection tests which the computer completed successfully. Full evaluation of FTMP and SIFT will be carried out at Langley Research Center in AIRLAB, the new Avionics Integration Research Laboratory. In FY 1984, this evaluation program will focus on the development of analytical fault insertion methods which will surpass the reliability estimation capability of conventional techniques.

HUMAN FACTORS - The goal of human factors research is to develop a fundamental understanding of the capabilities and limitations of aircraft crews in order to identify and solve human-related problems that impede the growth of aviation. One major element of this research is to enhance crewmember cognitive and perceptual capabilities by providing cockpit displays of traffic information (CDTI). During FY 1982, researchers at Ames Research Center developed a three-dimensional perspective CDTI format (Figure 14), which has been shown by initial simulator studies, to enable pilots to react more quickly and accurately than did prior two-dimensional formats.

In FY 1984, full-mission simulator evaluations of the new display will be carried out in the Man-Vehicle Systems Research Facility, which will become operational in FY 1983 at the Ames Research Center. Studies will be conducted both in the conventional cab and in an advanced cab, depicted in the figure, to evaluate the new display for potential use in current and next generation

aircraft.

COMPUTER SCIENCE - In FY 1983, following an intensive planning effort, a computer science research program was initiated. The program is directed toward advancing and applying aspects of computer science that are of special importance to aerospace applications. As shown in Figure 15, the research focuses on highly reliable computing, concurrent processing, and information management.

The goal of the reliable computing research thrust is to characterize software failure processes through analytical and experimental investigations of fault tolerant software reliability models. Concurrent processing research addresses system architectures and algorithms for computationally intensive problems in aerospace research. OAST is planning to establish a new Research Institute for Advanced Computer Science (RIACS) at Ames Research Center to conduct research in computer science and engineering in areas of potentially long-term application to NASA programs.

Information management research focuses on exploiting technical advances in computers to aid the engineering design and analysis process. The Integrated Programs for Aerospace-vehicle Design (IPAD) program is continuing research on large-scale design data base management. Techniques to handle basic geometry in a multi-view environment have been implemented and are undergoing evaluation. Efforts in FY 1984 and beyond will concentrate on establishing IPAD data base management software on a CDC host computer with full geometry capability and limited computer networking.

A major component of the computer science and applications program is to provide state-of-the-art high performance computational resources for aerospace research. A CRAY 1S-1300 computer with a CDC dual 720 support computer has been installed at Ames Research Center, and a CRAY 1S-2200 computer using an IBM 370/3033 attached processor for input and output services has been installed at Lewis Research Center. These systems support computations in fluid dynamics, chemistry, and thermal and structural analysis.

PROPULSION - An important goal of the propulsion program is to advance numerical analysis of components and engine systems to a state of practical application. Currently, detailed flow-field data for propulsion components are being acquired at Lewis Research Center to guide and

verify analytical code development. As an example, results of a three-dimensional viscous analysis recently obtained for a yawed axisymmetric supersonic inlet are shown in Figure 16. The analysis will be experimentally verified in FY 1984, allowing development of an analytical approach to improving inlet performance at yaw angles. It will then be possible to design three-dimensional conformal inlets for improved propulsion/airframe integration both for design and for off-design conditions.

Detailed flow-field measurements for turbine engine components will be used to establish a solid data base for analytical development. Initial data are being acquired for hot components, such as combustors and turbines, and testing is being extended to several fan and compressor configurations in FY 1983. In FY 1984 and beyond, the data base will be extended to more detailed documentation of the viscous and secondary flows of rotating components.

The focus of recent engine system dynamics research has been on the analytical modeling and verification of high frequency response characteristics, including pressure and temperature distortion effects. Figure 17 shows time histories of pressure and temperature data and illustrates compressor stall resulting from a rapid increase in inlet temperature applied during engine testing. This research is moving into a more extensive investigation of the stall phenomena, including methods to avoid stall or enhance the ability to recover from it. Experimental investigations of a high bypass ratio engine and a three-stage compressor have been initiated recently to determine stall triggering mechanisms, establish the stall sensitivity to various system features, and measure in-stall component performance. FY 1984 research will focus on determining engine control modes to improve recoverability, improving analytical models of the engine system dynamics during stall, and continuing compressor component modeling and experiments.

The Energy Efficient Engine Systems Technology program, which will be completed in FY 1983, is nearing its objective of developing and demonstrating advanced technology for a new generation of fuel efficient turbofan engines. The results have met or exceeded individual component goals. When translated into turbofan engine peformance levels, the results show a 15 percent reduction in fuel consumption, a 5 percent reduction

in direct operating cost, a 50 percent improvement in performance retention, and reduced environmental impact compared to current high bypass ratio commercial turbofan engines. The Pratt & Whitney high pressure turbine, the second build of the General Electric high pressure compressor, and the General Electric engine core, all shown in Figure 18, were tested during FY 1982. The General Electric core - consisting of the high pressure compressor, the combustor, and the high pressure turbine - exhibited excellent starting characteristics, good integrated component performance, and an overall efficiency that exceeded program goals.

During FY 1983, the General Electric core will be integrated with the low spool components to evaluate system interaction effects such as starting, transient capability, and performance of integrated components in a realistic engine environment. All previously planned component technology development efforts have been completed, and efforts in high payoff component technologies, such as hollow fan blade fabrication and high pressure ratio compressors, have been increased. The program has established an advanced technology base that will support significant improvements in the next generation of turbofan engines.

The Advanced Turboprop Systems Technology program continues to show favorable progress in critical technical areas, maintaining the potential for 15 to 20 percent fuel savings relative to equally advanced turbofans. Noise source and propagation predictions have been confirmed in the JETSTAR acoustic flight program. In addition, wind tunnel tests of propeller/nacelle/wing models have shown remarkable success in eliminating interference drag. While many challenges remain, no technical barriers have been encountered to date.

A contract to Hamilton Standard for design, fabrication, and test of large-scale (9-foot diameter) propfan blades (Figure 19) was awarded in July 1982. These blades will incorporate the same materials and structural design as full-scale blades; testing will determine fatigue life, natural frequencies and mode shapes, and blade retention strength. A second major contract activity will combine an existing engine, a modified gearbox, and a new nacelle into a test assembly for powering the large-scale propellers to explore other structural and dynamic characteristics. Subscale model research will continue in FY 1983 and include wind tunnel tests of two core-inlet models and the design

of an aeroelastically-scaled model of the large-scale propeller.

General aviation and commuter aircraft require substantially smaller engines than transport aircraft. Small gas turbine engines have unique components, as shown in Figure 20, that exhibit efficiencies 8 to 10 percent lower than large engine components. Therefore, efforts to increase the thermal efficiency, reliability, and durability of small turbine engines are directed toward developing a fundamental understanding and analytical data base of the flow phenomena and heat transfer for these small components.

In FY 1982, design studies for scaled centrifugal compressors were completed; a fabrication technique was developed for a radial turbine rotor with high effectiveness cooling; and a small reverse-flow combustor with an advanced liner cooling technique was evaluated at high temperature. Development of three-dimensional codes to predict viscous and secondary flow effects, predominant in small component flow fields, was also begun in FY 1982. Ongoing efforts are emphasizing expanded component activity to provide research hardware to study scale effects. Also, efforts on prediction techniques for combustor aerothermodynamics and fuel atomization characteristics are continuing. In FY 1984, detailed flow mapping of turbomachinery blade passages will provide data to verify models and analyses.

ROTORCRAFT - The technical goal of the rotorcraft program is to provide ground-based and flight research which will allow exploitation of the full potential of advanced rotorcraft for military and civil application. Ongoing research and technology efforts are focused in the areas of aerodynamics; flight dynamics and control; man-machine integration; structural dynamics; and wind tunnel, simulation and flight experiments support. Special attention is being given to aeroacoustics research into helicopter noise prediction. NASA has joined with the U.S. helicopter industry in a fundamental research program to develop improved predictions of helicopter noise for new and derivative designs. This program is now underway with the cooperation of the American Helicopter Society (AHS), the FAA, and the Helicopter Association International (HAI), and with participation by four U.S. helicopter firms.

A number of program milestones were achieved in rotorcraft technology in the past year, as shown in Figure 21. Completion of a fully documented finite

element analysis methodology was a major achievement in large transmission technology, laying the groundwork for increased confidence in the design of future spiral bevel gears. The analytical predictions of the complex gear loads and stresses compared well with measured data, and the documented computer programs are being released to the U.S. industry. Follow-on technology application efforts are now being supported by DOD; NASA research emphasis will shift to helicopter transmission noise prediction methodology.

A major milestone reached in the Rotor Systems Research Aircraft (RSRA) program, upper right of Figure 21, sets the stage for a new level of capability in rotorcraft flight research. After an extensive ground calibration and subsequent flight load surveys, the RSRA vehicles have reached full operational readiness and will play a critical role in the X-wing rotor flight investigation starting in FY 1984. Development and validation of a technique for predicting helicopter airframe vibrations have progressed significantly with the completion of analysis and tests using the CH-47 helicopter airframe, shown in the lower right of Figure 21. The results will be made available to the U.S. helicopter industry as the base for future research and technology efforts addressing optimization, sensitivity analyses, and vibration control during the helicopter design stage.

The XV-15 Tilt Rotor Research Aircraft program, shown in the lower left of Figure 21, is establishing an extensive data base through the proof-of-concept and military mission evaluations. One aircraft was dedicated to expand and fully document the operational envelope at normal and high gross weight conditions, including hover, level flight, conversions between hover and high speed flight, maneuvers, and high altitude test conditions. The second aircraft was used in extensive demonstration flights to assess the suitability of the concept for several military operational missions, including operations and nap-of-the-earth flying.

Figure 22 illustrates two of the operational evaluations of the XV-15 aircraft. On the left, the XV-15 painted in Navy colors, is shown operating from the deck of the U.S.S. Tripoli off the California coast. Initial results of those trials indicate no fundamental problems with the concept, including a complete lack of deck-edge upset tendencies when hovering with one rotor beyond the deck edge. Trials by the U.S. Army at Fort

Huachuca, Arizona, shown on the right, also successfully demonstrated the aircraft's inherent agility, maneuverability, and low altitude nap-of-the-earth suitability. The results of the XV-15 program to date are being made available to the Joint Service Advanced Vertical Lift (JVX) development team and the U.S. industry on an expedited basis.

An increasingly important aspect of rotorcraft technology is the integration of advanced aircraft and propulsion control to provide enhanced capabilities for the total system. Flight/propulsion control research, Figure 23, will receive increased emphasis in the FY 1984 rotorcraft program. UH-60 helicopter and T700 engine documentation will be used to develop a combined simulation model for the Ames Research Center Vertical Motion Simulator (VMS). This activity will provide a new capability in piloted simulation of aircraft/propulsion control integration. Further enhancement of the motion and visual capabilities of the VMS are underway under the sponsorship of the U.S. Army, as a part of joint research agreements with NASA. Following these modifications, extensive parametric studies and systems evaluation tasks will be conducted.

Using the broad scope of enabling technology now available, an augmentation in Technology for Next Generation Rotorcraft is planned for FY 1984, Figure 24. The XV-15 Tilt Rotor Research Aircraft program has recently been accelerated to provide an expanded data base in support of JVX design options. This activity will continue in FY 1984 in addition to long-term efforts focused on tilt rotor concepts incorporating advanced controls, fully integrated aero/propulsion concepts, and increased performance potential. The other activity in FY 1984 will be the start of a joint flight research program with the Defense Advanced Research Projects Agency (DARPA) to investigate the X-Wing concept using the unique capabilities now embodied in the RSRA flight research aircraft. The program will include supporting research and technology efforts, rotor design and fabrication, integration of the rotor and the RSRA, and flight tests.

SUBSONIC AIRCRAFT - The subsonic aircraft systems research program addresses the problems and opportunities that result from the integration of advanced technology components into vehicle systems. The spectrum of vehicle classes represented ranges from light general aviation aircraft, commuters, and small transports to the large commercial transports

and dedicated cargo/logistics vehicles. Technologies being addressed are, in large part, the outgrowth of efforts under the Aircraft Energy Efficiency (ACEE), General Aviation/Commuter, Terminal Configured Vehicle (TCV), and Aviation Safety programs.

The Advanced Transport Operating Systems program, which is complementary to the FAA's National Airspace System Plan, is the focus for many cooperative activities with the FAA and industry. The primary goal of this program, illustrated on the left of Figure 25, is to develop airborne systems concepts that will lead to increased effectiveness in the use of the nation's airspace and to enhanced aircrew effectiveness in current and future aircraft operations and air traffic control systems. In FY 1983, the activities include upgrading the B-737 flight facility and simulator for research on airplane systems that interface with the air traffic control system.

The Laminar Flow Control program, illustrated on the right of Figure 25, focuses on the technology needed for application of laminar flow designs to future aircraft. Based on recent advancements in materials and structures, several concepts have been identified which appear to be operationally feasible in terms of cost, weight, maintenance, inspection, and manufacturing. In FY 1983, two leading edge systems, with fully functional suction, surface insect/contamination protection, and anti-icing systems, will be completed and installed on the NASA JETSTAR aircraft. Ground and flight tests are scheduled for completion in late FY 1983.

Natural Laminar Flow (NLF) research is continuing during FY 1983 with exploration of practical methods for overcoming adverse environmental effects of ice formation and insect contamination, investigating the limits of NLF application, and developing analytical tools for industry to use in determining NLF wing production tolerances. In FY 1984, NLF research will continue developing analytical tools for optimizing wing geometry, airfoils, and surface finish to maximize the extent of laminar flow. Analytical and experimental definition of minimum drag configurations will be studied for laminar flow nacelles.

The Energy Efficient Transport (EET) program activities during FY 1983 will complete the first flight test validation of reduced fuel consumption. Conversion of the initial full-function active control system to a flight-capable test system is

also underway. Preliminary definition studies of the benefits of all-electric systems technology applied to large aircraft will be completed in FY 1983.

Evidence of engineering maturity of composite secondary aircraft structures was provided by the recent FAA certification and scheduled airline service of the B-767 and B-757 with over 3000 pounds of composite structure on each aircraft. Technology development programs for composite medium primary structures are rapidly being concluded (Figure 26) and industry's acceptance of this technology is reflected in new aircraft design studies, which incorporate both horizontal and vertical stabilizers made of composite structure.

To achieve the full potential of weight, fuel, and cost savings possible for composite primary structures, demanding technology development efforts will be needed to address critical design issues, shown on the right of Figure 26. The full use of composites in primary structures has the potential for providing up to 15 percent reduction in aircraft weight and cost. The Advanced Composite Structures Technology (ACST) program, illustrated in Figure 27, is proposed as an FY 1984 augmentation to provide the engineering data base and confidence required for application of composite primary structure to large civil and military transport aircraft designs in the 1990's. The approach is to obtain design data, verify analytical procedures for wing and fuselage sections, and evaluate improved materials with increased toughness and damage resistance. Development of wing technology will include establishing structural designs, focusing on critical design issues, and testing moderate sized wing box sections. The fuselage work will develop curved panel technology and conduct tests of intermediate size panels. The improved materials research will concentrate on developing tougher, more processable resin systems with higher strain limits, and increased resistance to damage.

Current stall/spin research in support of general aviation technology, depicted on the left of Figure 28, is focused on analytical prediction methods for aircraft stall/spin characteristics. Work is being completed on methods to maximize spin resistance and the safety margin for single engine aircraft. In addition, wind tunnel tests of twin engine aircraft configurations are being conducted to identify improvements for single engine operation characteristics of twin engine aircraft. During FY 1983, technology workshops were held at Langley

Research Center to solicit industry and FAA suggestions for future planning of NASA stall/spin programs for general aviation. The emphasis was on stall/spin resistance and prevention, FAA requirements, and industry evaluation and implementation of new concepts. In FY 1984, stall/spin research will continue to address twin engine aircraft designs.

Improved design techniques for aero/propulsion integration, illustrated on the right of Figure 28, offer the potential for significant reductions in total aircraft drag. Wind tunnel tests on conventional and advanced design, aft-mounted and NLF nacelles are being conducted in FY 1983 to investigate interference drag effects, and to determine minimum drag nacelle configurations and methods for their integration into commuter transport aircraft. Tests of aft-mounted, under-wing nacelles have shown a significant interference drag reduction of 50 percent compared to conventional installations.

The Langley F-106B severe storms research aircraft is continuing flights into convective weather to characterize direct lightning strikes, winds, and turbulence to improve lightning protection design concepts. During the 1982 season, the aircraft collected 156 direct strikes. In FY 1984, data will be collected at various altitudes and conditions for more complete determination of environmental conditions.

Flight test data obtained in actual icing conditions in the Lewis Research Center icing program will be evaluated for use in improving the forecast of icing conditions, in support of the recommendations by the Office of the Federal Coordinator for Meteorological Research and Supporting Services. Analytical predictions and characterization of actual ice accretion on unprotected airfoils are continuing, and ice protection concepts, such as the electromagnetic impulse system, will be tested on a composite structure wing in the Icing Research Tunnel in FY 1984.

HIGH PERFORMANCE AIRCRAFT - The High Performance Aircraft program is directed toward technologies primarily for military fighter applications, but which also offer future benefits for civil aircraft applications. Currently, the cost, complexity, and life expectancy required of these multi-mission aircraft demand advanced technology and improved design methods. Consequently, the NASA in-house research activities, conducted as cooperative

efforts with U.S. industry, emphasize developing extensive data bases and prediction techniques critical to these needs.

The F-16XL, shown at the top left of Figure 29, is the culmination of a cooperative program that began in 1975 between General Dynamics Fort Worth Division and Langley Research Center. The objective was to modify the NASA supersonic cranked arrow wing concept, developed as a large-scale SST wing, to improve the supersonic range and payload growth potential for the F-16E fighter aircraft during its planned production run. NASA is also conducting a cooperative program with McDonnell-Douglas, initiated in FY 1982, to provide the data base and design methods for advanced multi-mission aircraft capable of transonic maneuvering, sustained supersonic cruise, and reduced take-off and landing lengths for damaged runway conditions.

The planforms of four aircraft concepts undergoing systematic performance evaluations for a consistent set of mixed-mode mission criteria are shown on the right of Figure 29. Trapezoidal and swept wing concepts are being compared with the more recent and less well defined NASA cranked arrow and tailored leading edge Ogee concepts. In this FY 1984 cooperative program, NASA is concentrating on analysis, conceptual design, computational fluid dynamics, and performance validation by testing over the full range of operating flight speeds. Industry is addressing preliminary design, sizing, structural design and weight, system integration, and mission requirements.

In powered lift research and technology for military V/STOL applications, emphasis continues on analytical prediction methods for efficient and effective single and twin engine concepts (Figure 30). Aerodynamic performance characteristics for several twin engine, high speed fighter/attack concepts were obtained in FY 1982 tests using remote augmentor lift and ejector systems. Testing of two promising single engine concepts and a one-sixth scale free flight model of one concept will be tested in FY 1984. In addition, aerodynamic and control characteristics of a one-third scale ejector, shown in the lower left of Figure 30, will be evaluated at Lewis Research Center.

New high speed aircraft propulsion simulators are shown on the lower right of Figure 30. These simulators, which performed successfully in recent tests as isolated components, will be installed in an aircraft model for evaluation of engine/airframe

interaction effects. Recent tests of a fan with controllable inlet guide vanes demonstrated that this method of thrust modulation can be successfully controlled over the total thrust range. In addition, a variable pitch rotor blade concept will be tested in FY 1984 to study performance and thrust modulation.

NASA high performance flight research activity has increased through a variety of joint and cooperative technology programs with DOD. The Advanced Fighter Technology Integration (AFTI) program is a joint program with the Air Force. One element of the program addressing the AFTI/F-16, shown in the upper left of Figure 31, was initiated in FY 1982 to evaluate advanced fire/flight control system technologies applicable to increased air-to-air and air-to-ground weapons delivery accuracy. Flight testing is currently underway at Dryden Flight Research Facility and will continue in FY 1984. Flight tests of the AFTI/F-111, with a variable camber/mission adaptive wing configuration being fabricated by Boeing, will be conducted in FY 1984 to evaluate increased performance in range and transonic maneuverability (upper right of Figure 31).

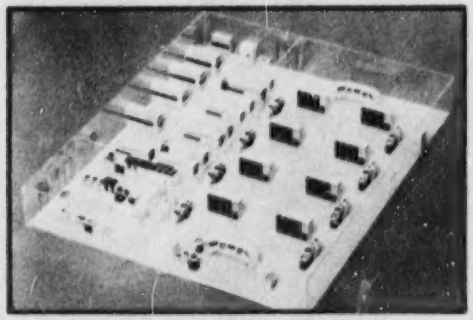
NASA is a major partner in the joint forward swept wing (X-29A) program with the Air Force and DARPA. The aircraft design, being built by Grumman, includes advanced aerodynamic, structures, and control technologies in order to evaluate the potential benefits of reduced aircraft size and weight, increased transonic maneuverability, and improved low speed performance. Extensive wind tunnel tests, computational analysis, and ground tests at Langley and Ames Research Centers will be conducted in preparation for flight testing scheduled at Dryden in FY 1984.

In a cooperative program with the Air Force, NASA will install a decoupler pylon on an F-16 to evaluate a passive wing-store flutter suppression system. The pylon is currently being built by General Dynamics with flight tests scheduled at Dryden in FY 1984. Test results will be used by the Air Force and industry to improve weapons/aircraft design compatibility.

The summary we have presented today contains highlights of our proposed FY 1984 aeronautics program. We believe the program is responsive, within current budgetary constraints, to the policies recommended in the OSTP report and expressed by this Committee. The FY 1984 budget

request builds positively on the momentum that has been generated with your support in the past. With your continued support and approval of our request, I am certain that we can move effectively toward satisfying our mutual objectives and developing the technology required for superior future U.S. civil and military aircraft.

AERONAUTICAL FACILITIES

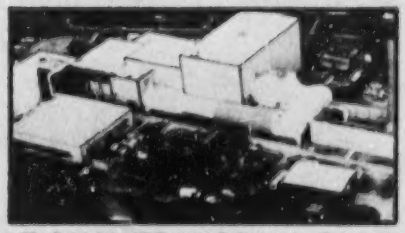


AVIONICS INTEGRATION
RESEARCH LABORATORY

CONSTRUCTION OF FACILITIES

40 BY 80 BY 120-FOOT
WIND TUNNEL

MAN-VEHICLE SYSTEMS
RESEARCH FACILITY



NATIONAL TRANSONIC FACILITY

NASA

OAST NASA HQ RJ83-839 (3)
1-18-83

Figure 1

AERONAUTICAL RESEARCH AND TECHNOLOGY

R&D BUDGET ($M)

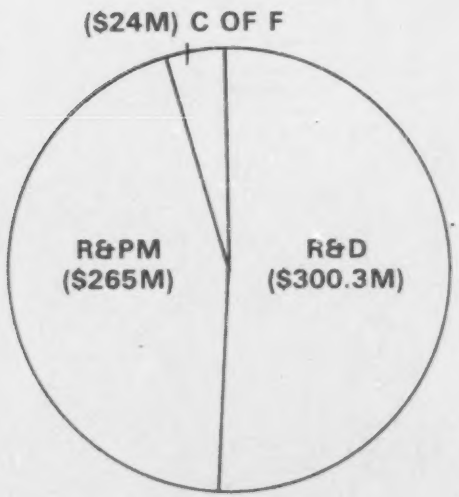
	FY 1982	FY 1983	FY 1984
RESEARCH & TECHNOLOGY BASE	172.7	197.7	227.8
SYSTEMS TECHNOLOGY PROGRAMS	92.1	82.3	72.5
TOTAL	264.8	280.0	300.3
DIRECT CIVIL SERVICE POSITIONS	3,753	3,739	3,740

NASA

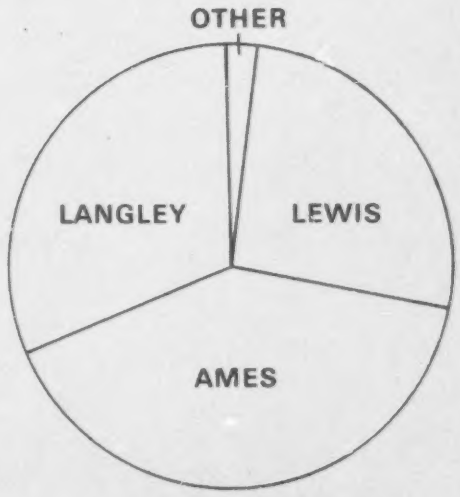
Figure 2

OAST NASA HQ RM83 778 (3) 1-14-83

NASA AERONAUTICS PROGRAM
FY 1984



TOTAL $589M



R&D $300.3M

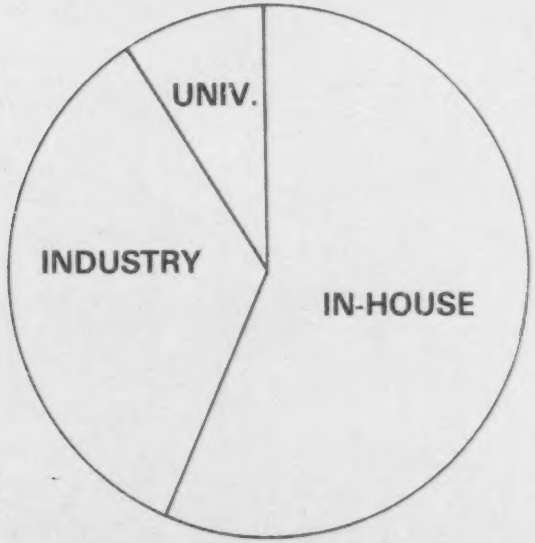
NASA

OAST NASA HQ RM83-777 (3) 1-14-83

Figure 3

AERONAUTICAL RESEARCH AND TECHNOLOGY

FY 1984 R&D BUDGET



$300.3M

NASA

Figure 4

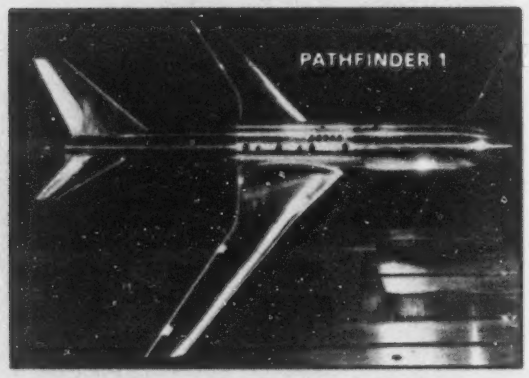
OAST NASA HQ RMS3 776 (3)
1 14 83

HIGH REYNOLDS NUMBER AERODYNAMICS

FLUID AND THERMAL PHYSICS

NATIONAL TRANSONIC FACILITY

- CONSTRUCTION COMPLETED
- SHAKEDOWN/CALIBRATION UNDERWAY



INITIAL CHECK-OUT TESTS

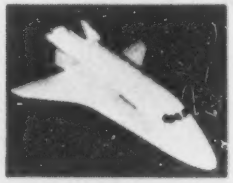
BENCHMARK
TRANSONIC FLIGHT REYNOLDS
NUMBER EXPERIMENTS

WIND TUNNEL/FLIGHT CORRELATIONS

BOEING 767

PATHFINDER II
FIGHTER

SHUTTLE



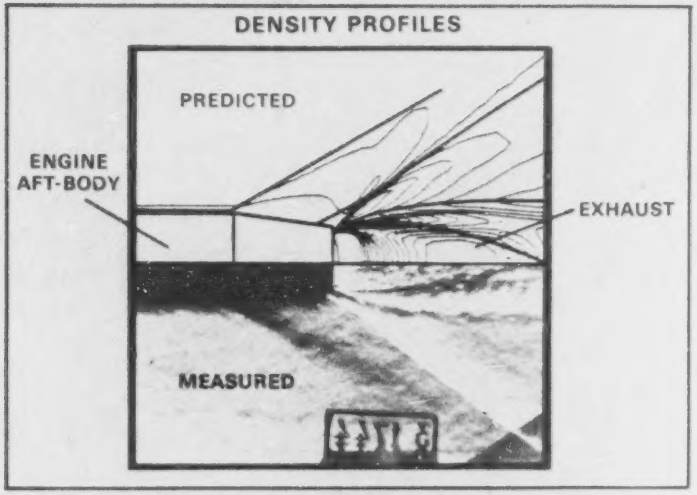
NASA

Figure 5

OAST NASA HQ RJ83-806 (3)
1-14-83

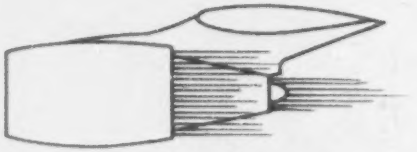
AIRFRAME/PROPULSION INTEGRATION

FLUID AND THERMAL PHYSICS



2-D ANALYSIS VERIFIED WITH
WIND TUNNEL DATA

DRAG REDUCTION THROUGH
COMPUTATIONAL
FLUID DYNAMICS



EXTEND TO 3-D
NON-SYMMETRICAL
FLOW CONDITIONS

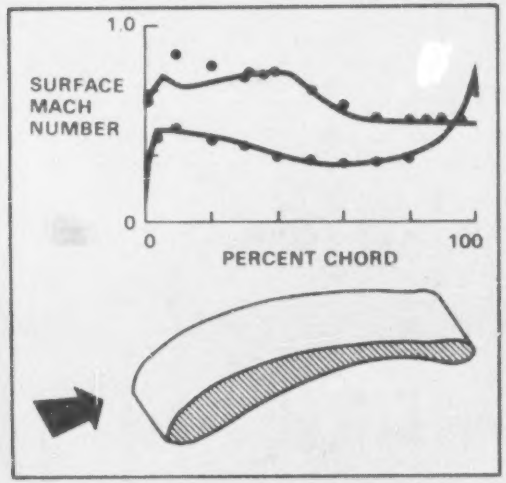
NASA

Figure 6

OAST NASA HQ RJ83-809 (3)
1-14-83

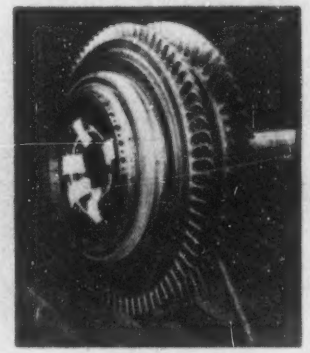
TURBOMACHINERY FLOW ANALYSIS

FLUID AND THERMAL PHYSICS



2-D VISCOUS COMPRESSOR BLADE CODE DEVELOPED

3-D SIMULATION OF MULTIPLE BLADE ROWS



INCORPORATE 3-D VISCOUS EFFECTS

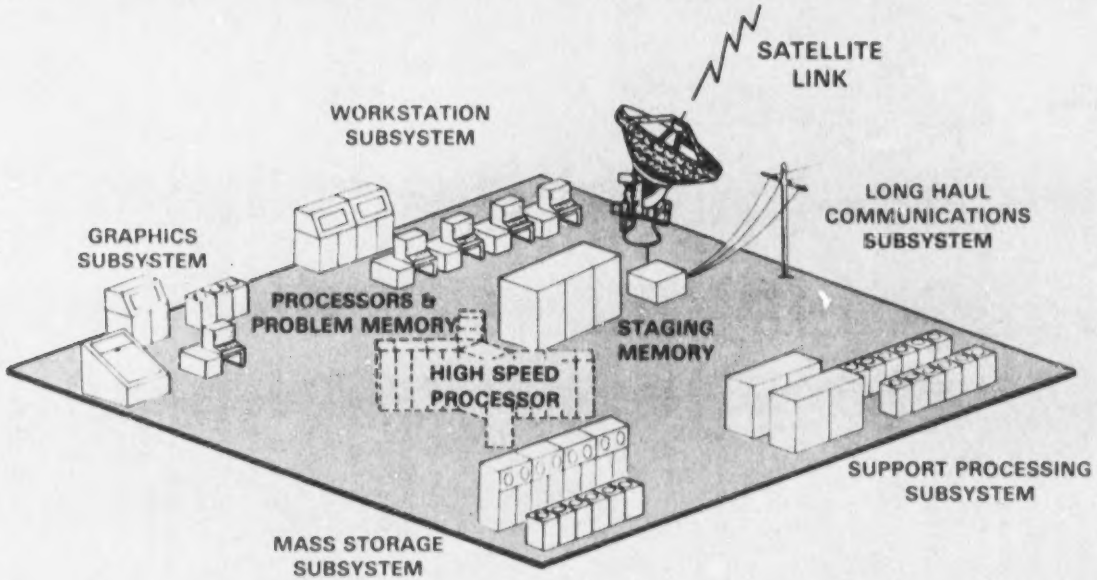
NASA

Figure 7

OAST NASA HQ RJ83-808 (3) 1-14-83

NUMERICAL AERODYNAMIC SIMULATION

SIGNIFICANT ADVANCE IN COMPUTATIONAL CAPABILITY



NASA

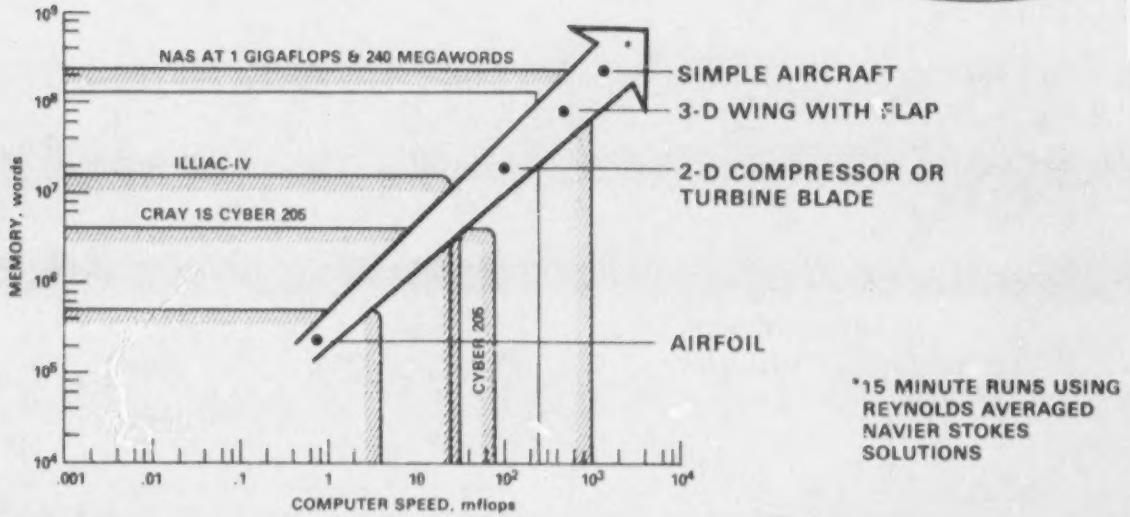
Figure 8

OAST NASA HQ RT82 1361 (3) Rev. 10-29-82

NUMERICAL AERODYNAMIC SIMULATION

ADVANCING COMPUTER CAPABILITIES

EFFICIENT AIRCRAFT DESIGN TECHNIQUES



*15 MINUTE RUNS USING REYNOLDS AVERAGED NAVIER STOKES SOLUTIONS

NASA

Figure 9

OAST NASA HQ RJ83-812 (3) 1-14-83

HIGH TEMPERATURE TURBINE MATERIALS

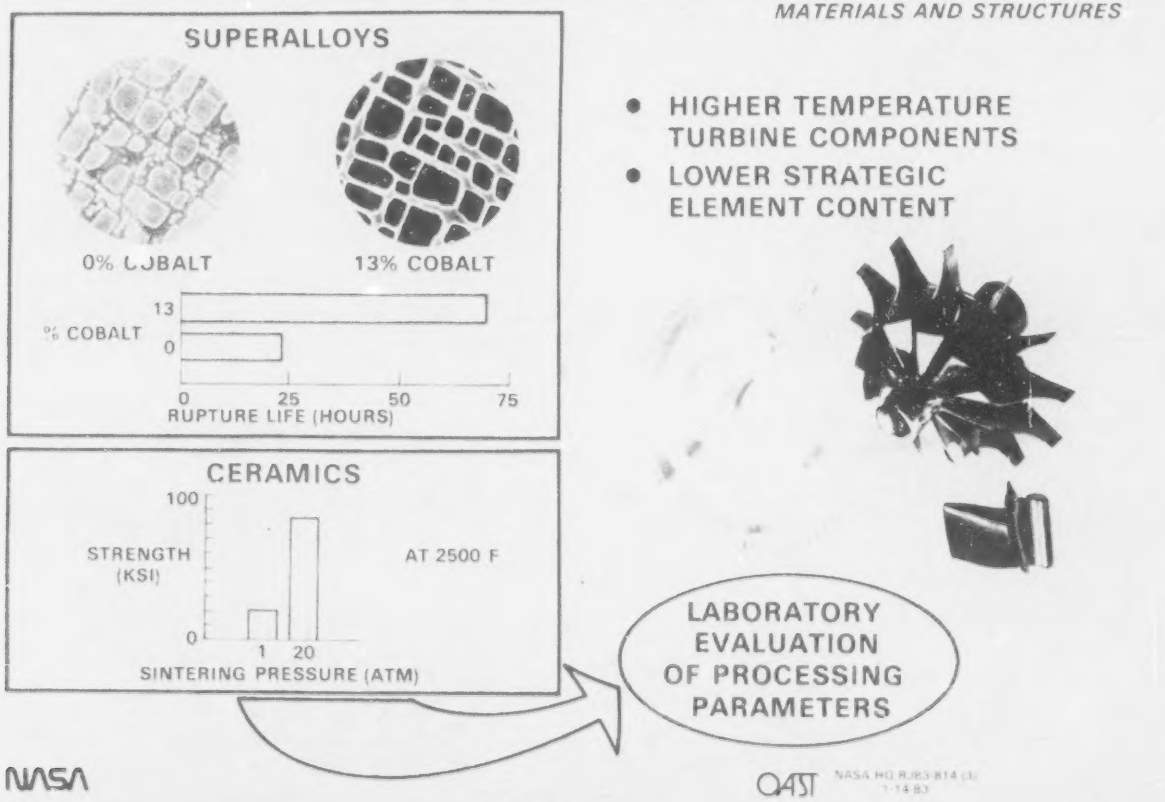
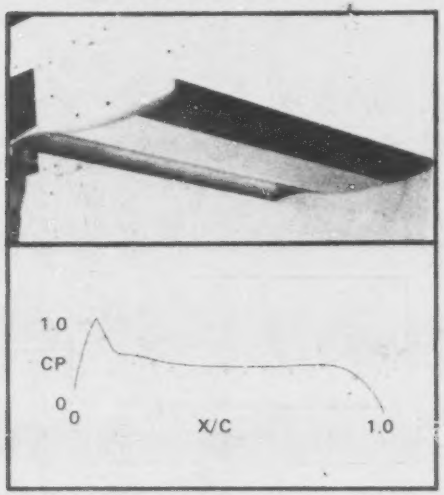


Figure 10

AIRCRAFT AEROELASTICITY

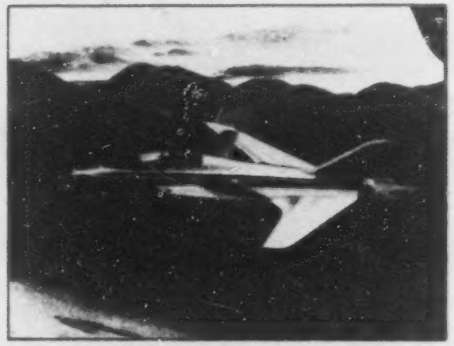
MATERIALS AND STRUCTURES

RECTANGULAR SUPERCRITICAL WING



VERIFIED 2-D AEROELASTIC MODEL

ADVANCED AIRCRAFT CONCEPTS
THROUGH IMPROVED AEROELASTIC
PREDICTIVE METHODS



EXTEND TO INCORPORATE
3-D FLOW EFFECTS

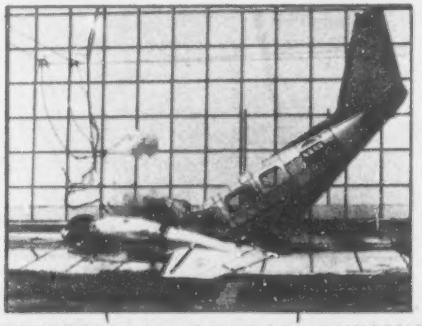
NASA

OAST NASA HQ RJ83-824 (3)
1-14-83

Figure 11

AIRCRAFT CRASH DYNAMICS

MATERIALS AND STRUCTURES



GENERAL AVIATION CRASH DYNAMICS

DESIGN CRITERIA FOR
TRANSPORT CRASHWORTHINESS

STRUCTURAL CONCEPTS FOR
ENERGY ABSORPTION

MODEL DEVELOPMENT/
VALIDATION THROUGH
FULL SCALE TRANSPORT
CRASH

NASA

OAST

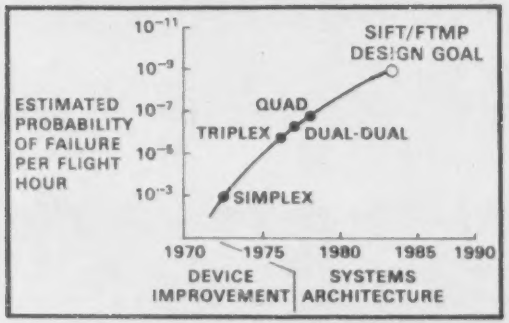
Figure 12

FAULT TOLERANT COMPUTERS

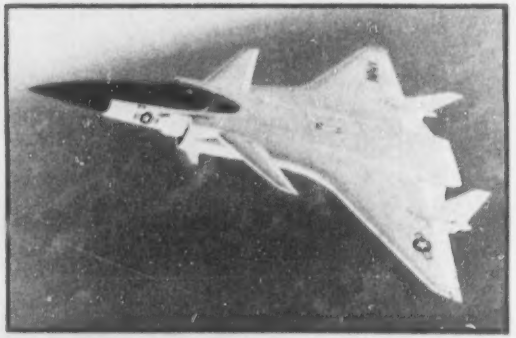
CONTROLS AND GUIDANCE

PIONEERING COMPUTERS DEVELOPED

- SIFT — SOFTWARE IMPLEMENTED FAULT TOLERANCE
- FTMP — FAULT TOLERANT MULTIPROCESSOR



HIGHLY RELIABLE FLIGHT CRUCIAL ELECTRONIC FLIGHT CONTROL SYSTEMS



EVALUATION IN AVIONICS INTEGRATION RESEARCH LABORATORY

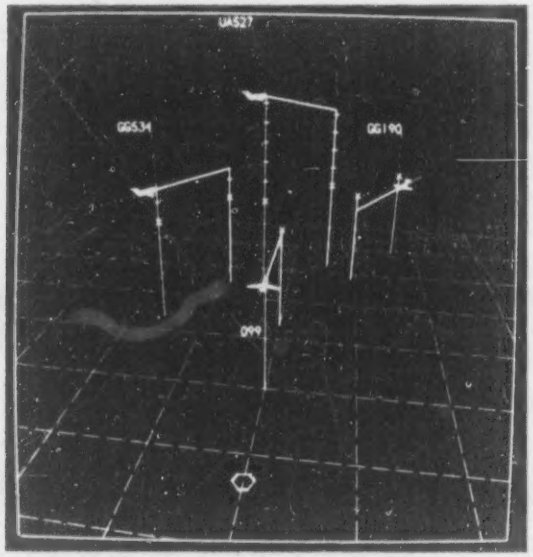
NASA

OAST NASA HQ RJ83-823 (3) 1-14-83

Figure 13

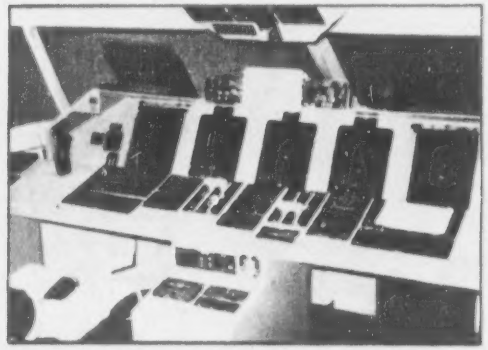
COCKPIT DISPLAY OF TRAFFIC INFORMATION

HUMAN FACTORS



3-D PERSPECTIVE DISPLAY CONCEPT

INCREASE AIRSPACE CAPACITY
AND SAFETY



EVALUATE IN
MAN-VEHICLE SYSTEMS
RESEARCH FACILITY

NASA

OAST

Figure 14

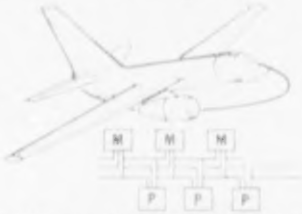
COMPUTER APPLICATIONS TO AERONAUTICS

COMPUTER SCIENCE AND APPLICATIONS

PROGRAM FOCUS

- RELIABLE COMPUTING
- CONCURRENT PROCESSING
- INFORMATION MANAGEMENT

INCREASED EMPHASIS IN CONCURRENT PROCESSING



FAULT TOLERANT COMPUTERS

COMPUTATIONAL ANALYSIS

INTERACTIVE DESIGN

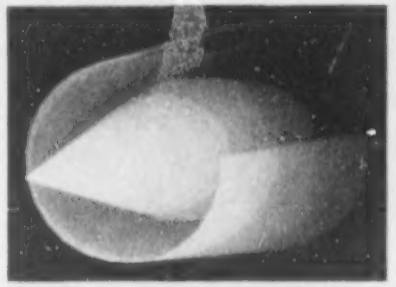
NASA

OAST

Figure 15

SUPERSONIC INLETS

PROPULSION

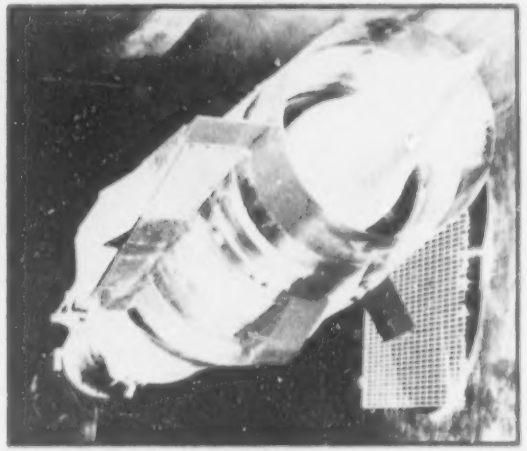


LEEWARD FLOWFIELD

STATIC PRESSURE FIELD

3-D VISCOUS FLOW PREDICTION
FOR YAWED AXISYMETRIC INLET

OFF-DESIGN ANALYSIS FOR
AXISYMETRIC AND
INITIAL ANALYSIS FOR 3-D
CONFORMAL INLETS



EXPERIMENTAL
VERIFICATION IN
WIND TUNNEL

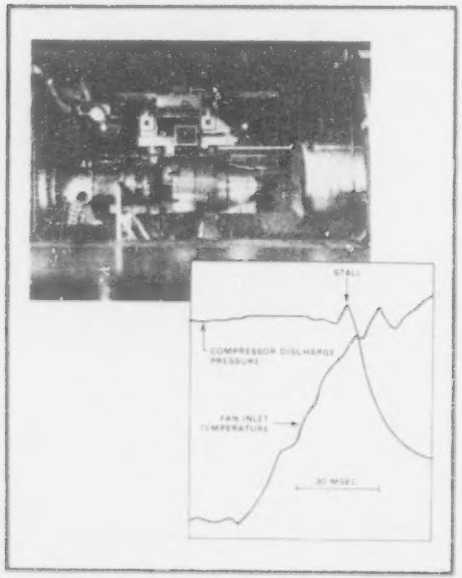
NASA

OAST

Figure 16

ENGINE SYSTEM DYNAMICS RESEARCH

PROPULSION



RESPONSE TO PRESSURE AND TEMPERATURE FLUCTUATIONS

STABLE, RECOVERABLE PROPULSION SYSTEMS

- DYNAMIC MODELING TECHNIQUES
- CONTROL MODES FOR RECOVERY
- COMPRESSOR STALL CHARACTERISTICS

DETERMINE ENGINE AND COMPRESSOR IN-STALL CHARACTERISTICS

NASA

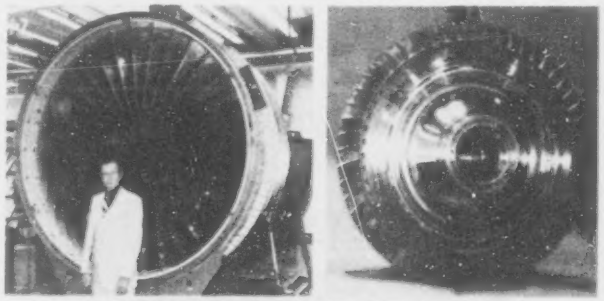
OATSI NASA HQ RJR3 838 (3) 7-19-83

Figure 17

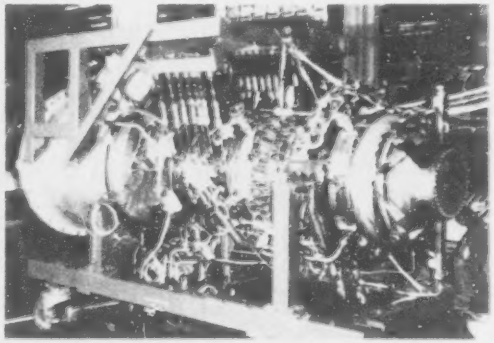
ENERGY EFFICIENT ENGINE

PROGRAM COMPLETED FY1983

PROPULSION



HIGHLY SUCCESSFUL
COMPONENT TECHNOLOGY
DEVELOPMENT



CORE TECHNOLOGY
EVALUATION SUCCESSFULLY
COMPLETED

- TECHNOLOGY DEVELOPED FOR 15% IMPROVEMENT IN FUEL CONSUMPTION

NASA

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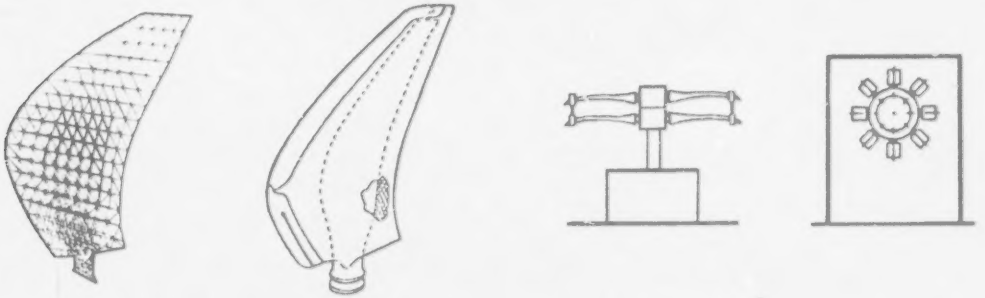
NASA HQ RJB3-615(3)
1-14-83

Figure 18

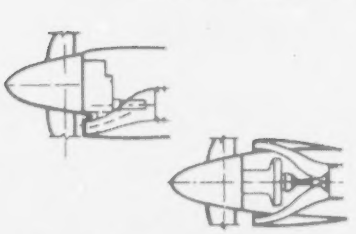
ADVANCED TURBOPROP

FY1983 PROGRAM

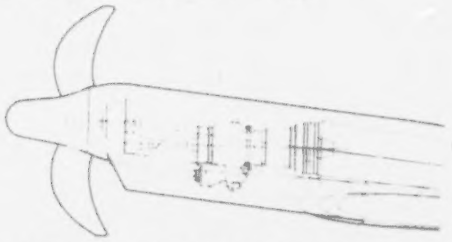
PROPULSION



LARGE-SCALE BLADE DESIGN, FABRICATION, TEST



INLET MODEL TEST



PROPELLER TEST ASSEMBLY PREPARATION

NASA

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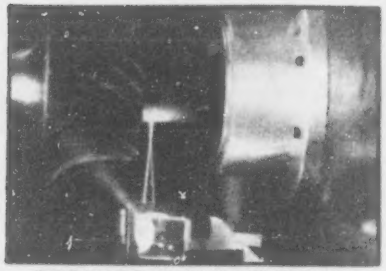
Figure 19

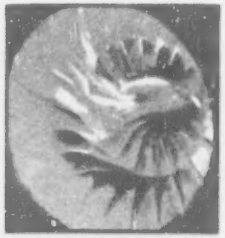
SMALL GAS TURBINE COMPONENT TECHNOLOGY

FY1983 PROGRAM

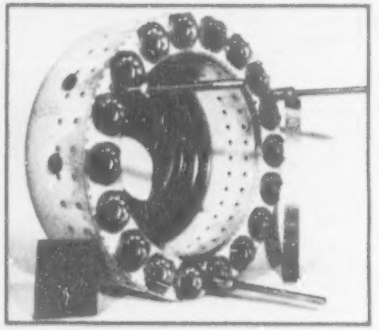
PROPULSION



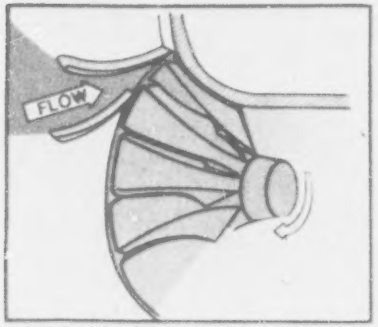
DETAILED FLOW MAPPING



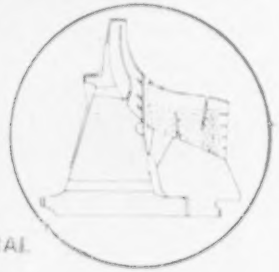
CENTRIFUGAL COMPRESSOR



REVERSE FLOW COMBUSTORS



VARIABLE FLOW CONCEPTS



COOLED RADIAL TURBINE

NASA

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Figure 20

ROTORCRAFT TECHNOLOGY PROGRAM

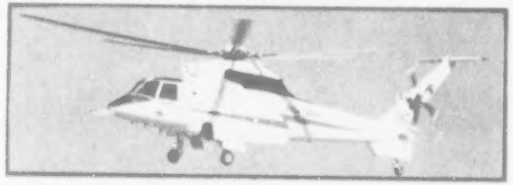
ROTORCRAFT

LARGE TRANSMISSION TECHNOLOGY

FINITE ELEMENT ANALYSIS

GEAR TESTS

ROTOR SYSTEMS RESEARCH AIRCRAFT



FULL OPERATIONAL STATUS

TILT ROTOR RESEARCH AIRCRAFT

PROOF-OF-CONCEPT

NASA

FINITE ELEMENT VIBRATIONS MODELING

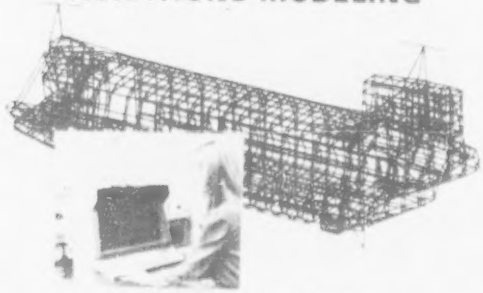


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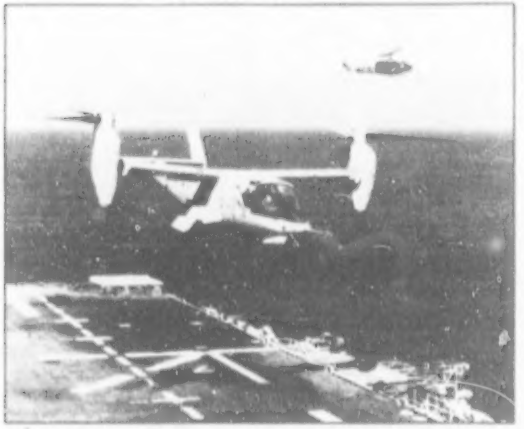
Figure 21

XV-15 TILT ROTOR OPERATIONAL EVALUATIONS



U.S. NAVY TRIALS ABOARD
U.S.S. TRIPOLI

U.S. ARMY TRIALS AT FORT
HUACHUCA, ARIZONA

NASA

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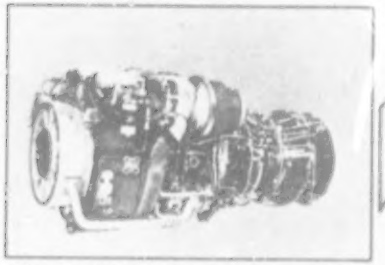
Figure 22

FLIGHT/PROPULSION CONTROLS RESEARCH

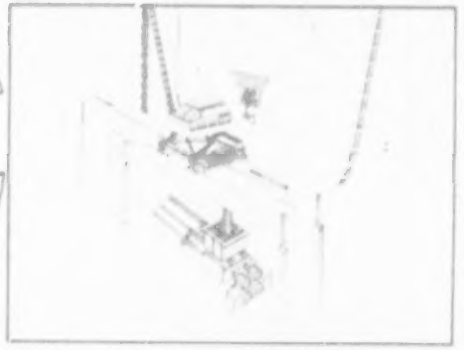
ROTORCRAFT

AIRCRAFT DATA BASE



PROPULSION DATA BASE

PILOTED SIMULATION



VERTICAL MOTION SIMULATOR

AIRCRAFT/PROPULSION CONTROL INTEGRATION

- PARAMETRIC STUDIES
- SYSTEM EVALUATIONS

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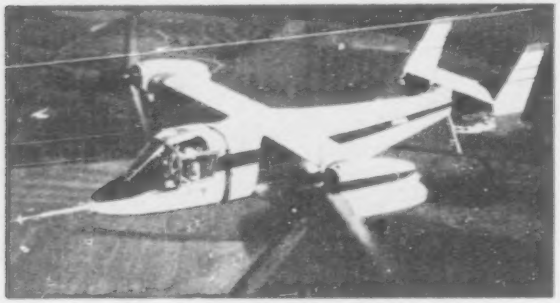
Figure 23

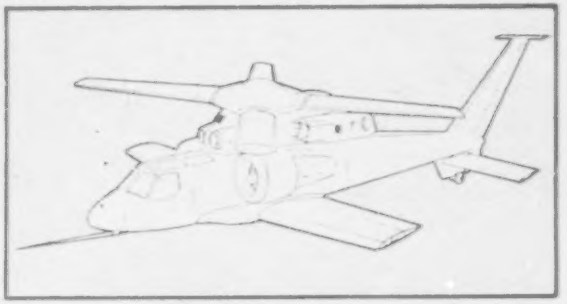
TECHNOLOGY FOR NEXT GENERATION ROTORCRAFT

FY1984 AUGMENTATION *ROTORCRAFT*



ADVANCED TILT ROTOR TECHNOLOGY

- PERFORMANCE
- CONTROLS
- AERO/PROPULSION INTEGRATION
- ADVANCED CONFIGURATIONS
- JVX SUPPORT



RSRA/X-WING FLIGHT PROGRAM DARPA/NASA

- ROTOR TECHNOLOGY DEVELOPMENT AND VALIDATION
- INVESTIGATE STOP-START CONVERSION
- UNIQUE RSRA CAPABILITY

NASA OAST NASA HQ RJB3 803 (3) 1-14-83

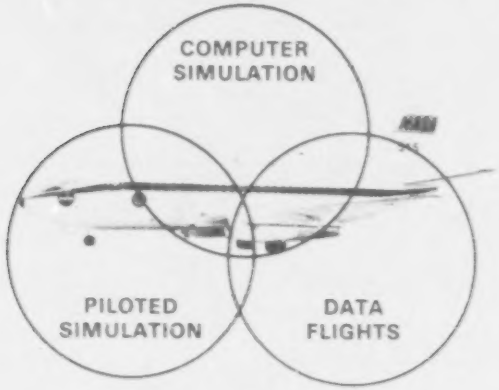
Figure 24

TRANSPORT TECHNOLOGY

FY1983 PROGRAM

SUBSONIC AIRCRAFT

ADVANCED TRANSPORT OPERATING SYSTEMS



EVALUATION

LAMINAR FLOW CONTROL

OPTIMIZED AIRFOIL AND SUCTION REQUIREMENTS

LEADING EDGE GLOVE FLIGHT TEST

NASA

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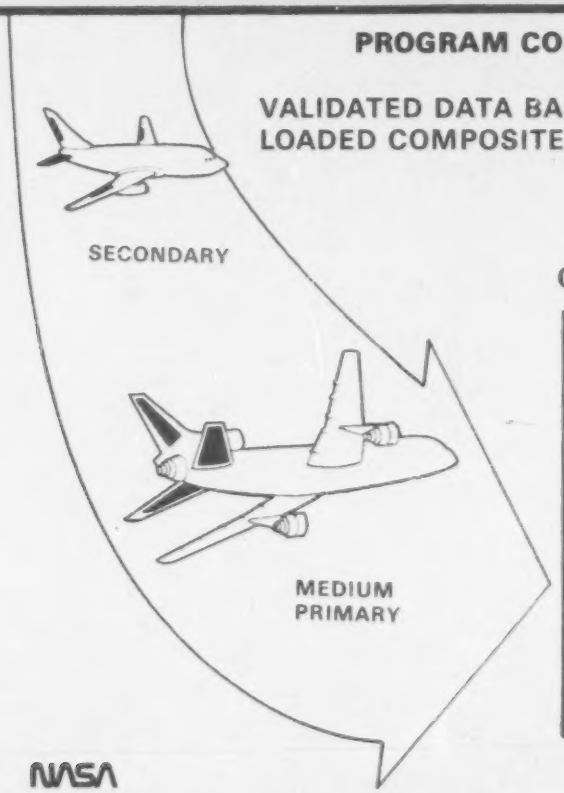
Figure 25

COMPOSITE PRIMARY AIRCRAFT STRUCTURES

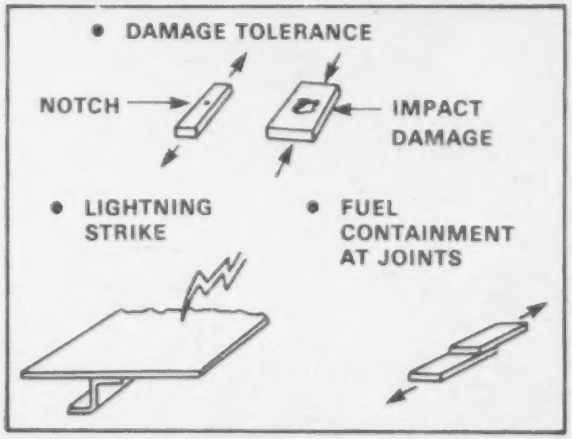
PROGRAM COMPLETED 1983

SUBSONIC AIRCRAFT

VALIDATED DATA BASE FOR LIGHTLY – LOADED COMPOSITE STRUCTURES



CRITICAL DESIGN ISSUES ADDRESSED



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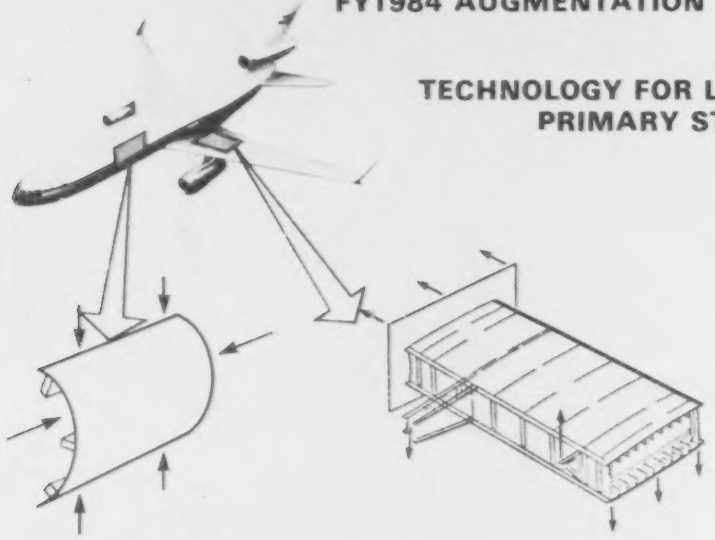
1-14-83

Figure 26

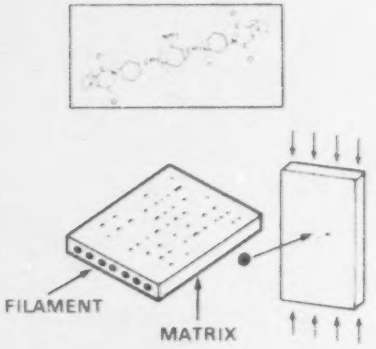
ADVANCED COMPOSITE STRUCTURES TECHNOLOGY

FY1984 AUGMENTATION

SUBSONIC AIRCRAFT



TECHNOLOGY FOR LARGE COMPOSITE PRIMARY STRUCTURE



FUSELAGE STRUCTURE

- CURVED PANEL DESIGN PARAMETERS
- POST-BUCKLED LOADING BEHAVIOR

WING STRUCTURE

- DAMAGE TOLERANT, STRENGTH CRITICAL STRUCTURE
- CERTIFICATION CRITERIA

MATERIALS

- TOUGHER, HIGHER STRAIN COMPOSITES
- MORE PROCESSABLE RESIN SYSTEMS

NASA

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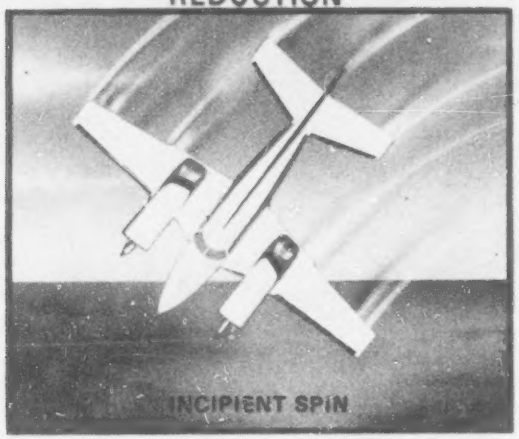
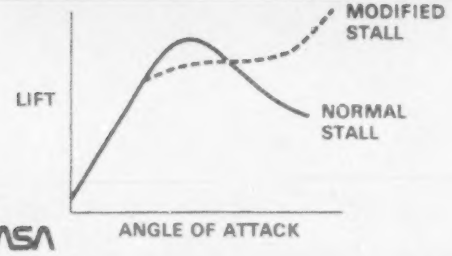
Figure 27

GENERAL AVIATION/COMMUTERS

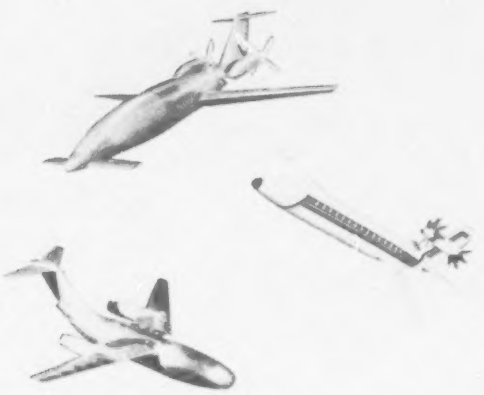
SUBSONIC AIRCRAFT

STALL/SPIN HAZARD REDUCTION





AERO/PROPULSION SYSTEM INTEGRATION



NASA

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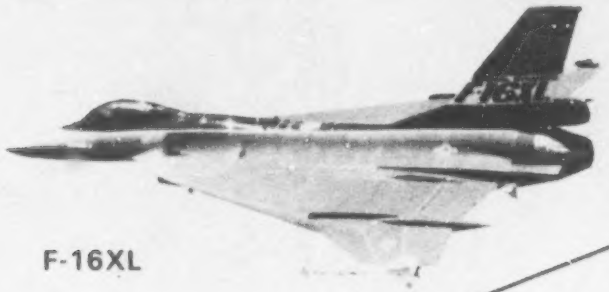
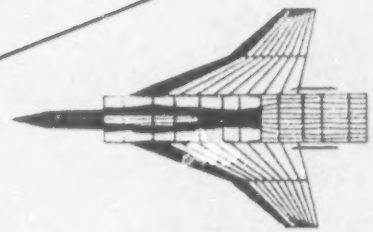
Figure 28

ADVANCED FIGHTER RESEARCH

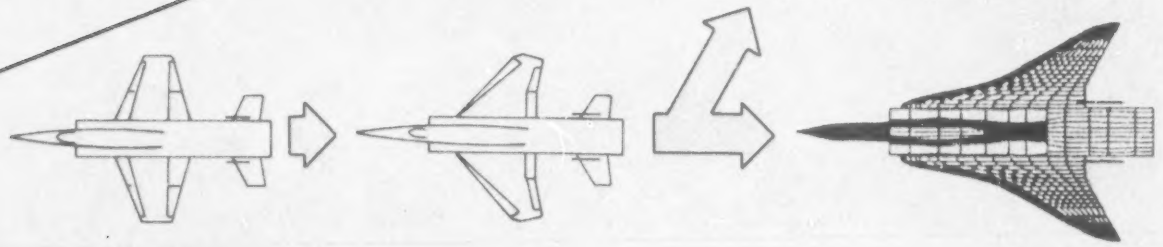
HIGH PERFORMANCE AIRCRAFT



F-16XL



CRANKED LEADING EDGE



TRAPEZOIDAL

SWEPT

OGEE-TYPE

NASA

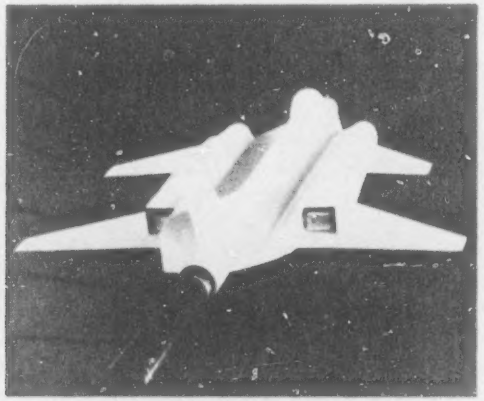
OAST

NASA HQ 383-801 (3)
1-14-83

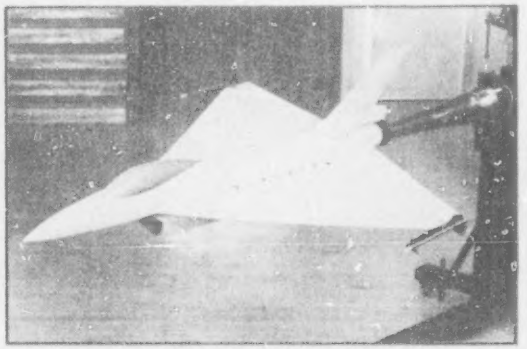
Figure 29

SUPERSONIC STOVL RESEARCH

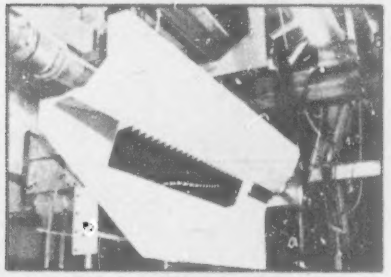
HIGH PERFORMANCE AIRCRAFT



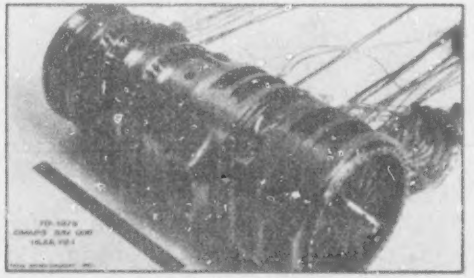
TWIN ENGINE FIGHTER



SINGLE ENGINE FIGHTER



EJECTOR TECHNOLOGY



PROPULSION SIMULATION

NASA

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Figure 30

APPENDIX I

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

JAN 31 1983

C:MDD:C-8649f

Honorable Dan R. Glickman
Chairman
Subcommittee on Transportation,
Aviation and Materials
Committee on Science
and Technology
House of Representatives
Washington, DC 20546

Dear Mr. Chairman:

Enclosed are the pre-hearing responses to the written questions on NASA's FY 1984 Aeronautics budget.

These responses complete the information requested for that day.

Sincerely,

for John C. Templeton

John F. Murphy
Assistant Administrator
for Legislative Affairs

Enclosures : A35391

RESPONSES TO WRITTEN QUESTIONS FROM CHAIRMAN GLICKMAN

QUESTION R-1:

Please tabulate the FY 1983 Operating Plan for Aeronautics, explaining any changes from the initial plan (budget request).

ANSWER R-1:

The increase of $48 million in aeronautical research and technology activities is directly attributable to a Congressional increase that provided continuing support for selected ongoing programs in the advanced propulsion, subsonic aircraft and rotorcraft systems technology areas. In advanced propulsion, Congressional action provided funding which allowed work to continue in FY 1983 on advanced turboprop systems, general aviation/commuter engine technology, broad property fuels and the energy efficient engine. In subsonic aircraft, the Congressional action provided funds for continued effort on composite primary aircraft structures, advanced transport operating systems, laminar flow control and energy efficient transport. In rotorcraft, the Congressional action provided additional funding for advanced rotorcraft technology.

The current FY 1983 Aeronautics budget total is $280 million. A tabular summary is provided below:

FY 1983 BUDGET CHRONOLOGY
($ in Millions)

Original Submission	232.0
Congressional Add-ons	+48.0
Current FY 1983 Operating Plan	280.0

A detailed comparison of the FY 1983 original submission and the current FY 1983 Operating Plan is enclosed.

QUESTION R-2:

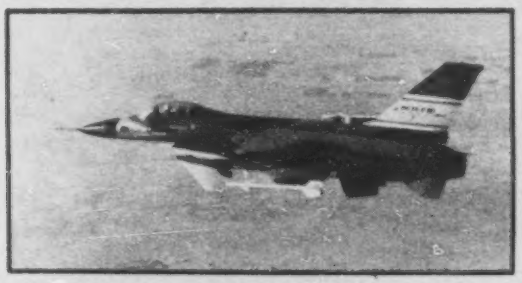
Please tabulate for fiscal years 1982 through 1988 runout costs of the current aeronautics program (broken out by standard budget sub-line items as presented in the R&D budget book). Also, please provide figures for one budget level below these sub-line items.

ANSWER R-2:

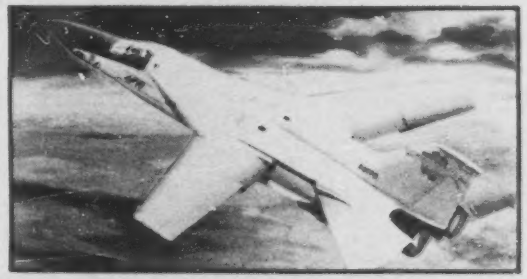
See the enclosed table.

HIGH PERFORMANCE FLIGHT RESEARCH
FY1984 PROGRAM

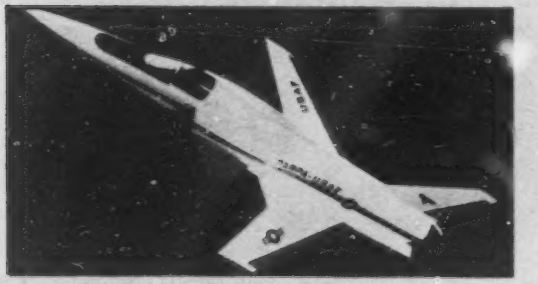
HIGH PERFORMANCE AIRCRAFT



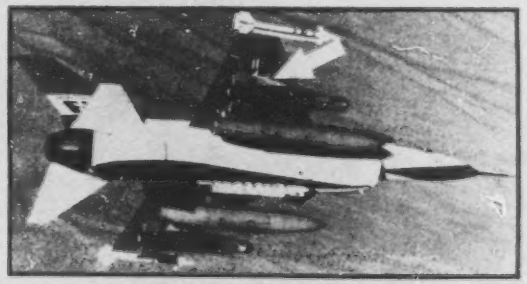
ADVANCED INTEGRATED
FLIGHT CONTROLS
(AFTI-16)



MISSION ADAPTIVE WING
(AFTI-111)



FORWARD SWEPT WING
(X-29A)



DECOUPLER PYLON
(F-16)

NASA

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1-14-83

Figure 31

FY 1983 AERONAUTICS OPERATING PLAN
BUDGET VS. CURRENT PLAN
($ in Thousands)

	BUDGET	Δ	CURRENT	EXPLANATION OF DIFFERENCES
Aeronautics	232,000	+48,000	280,000	
Research & Technology R&T Base	196,600	+1,100	197,700	Within the aeronautics research and technology base, an internal realignment of FY 1983 funding was implemented in order to place increased emphasis on high priority computer science and applications programs, and to provide additional support to supersonic and hypersonic cruise vehicles research.
Fluid & Thermal Physics R&T	46,100	-3,000	43,100	Reflects internal program redirection to support additional emphasis on computer science and applications and supersonic and hypersonic cruise vehicles research, with a reduction in turbomachinery noise minimization research.
Materials & Structures R&T	25,500	-800	24,700	Reflects internal program redirection to support additional emphasis on computer science and applications and supersonic and hypersonic cruise vehicles research, with a reduction in scope of the efforts

	BUDGET	△	CURRENT	EXPLANATION OF DIFFERENCES
				in lubrication, life prediction, and unsteady aerodynamics.
Controls & Guidance R&T	11,300	+600	11,900	Reflects a minor realignment within the R&T Base to support increased fault-tolerant avionics research.
Human Factors R&T	9,600	+600	10,200	Reflects a minor realignment within the R&T Base to support increased visual scene research associated with the Man-Vehicle Systems Research Facility at the Ames Research Center.
Multidisciplinary Research	3,500	-	3,500	
Computer Science & Applications R&T	14,200	+5,000	19,200	Reflects internal program redirection to support additional emphasis in computer science and applications programs such as the Integrated Program for Aerospace-vehicle Design (IPAD), and provides Class VI computing capability at the Ames and Lewis Research Centers.
Propulsion Systems R&T	18,600	-2,000	16,600	Reflects internal program redirection to support additional emphasis in computer science and applications and supersonic and hypersonic cruise vehicles research, with a reduction in turbomachinery components, combustion and fuels, and power transfer research.

	BUDGET	△	CURRENT	EXPLANATION OF DIFFERENCES
Rotorcraft R&T	21,800	+1,200	23,000	Reflects internal program redirection to support low-speed aerodynamics and noise research, and low-speed simulation and flight systems support activity.
High-Performance Aircraft R&T	35,700	+2,300	38,000	Reflects internal program redirection to increase emphasis on high-speed powered-lift short-takeoff and vertical landing (STOVL) supersonic design concept evaluations, and hypersonic vehicles.
Subsonic Aircraft R&T	10,300	-2,800	7,500	Refects internal program redirection to support additional emphasis in computer science and applications and supersonic and hypersonic cruise vehicles research, with a reduction in materials and structures and aerodynamic systems research.
Systems Technology Programs	35,400	+46,900	82,300	
Rotorcraft Systems Technology	20,600	+1,700	22,300	Reflects an increase in funding for the rotorcraft systems technology program in FY 1983 primarily as the result of Congressional direction to continue support of the advanced rotorcraft technology program.

	BUDGET	△	CURRENT	EXPLANATION OF CHANGES
High-Performance Aircraft Systems Technology	14,800	+200	15,000	Reflects decision to augment high-performance flight research, including support of joint NASA/DARPA X-29A forward swept wing flight demonstration program with an offsetting decrease to the HiMAT program reflecting decision to reduce its scope and accelerate its completion.
Subsonic Aircraft Systems Technology	-0-	+17,000	17,000	Reflects an increase in funding for the subsonic aircraft systems technology program activity in FY 1983 as the result of Congressional direction to continue support of ongoing activities in the following program areas: composite primary aircraft structures, advanced transport operating systems, laminar flow control, and energy efficient transport.
Advanced Propulsion Systems Technology	-0-	+28,000	28,000	Reflects an increase in funding for the advanced propulsion systems technology program activity in FY 1983 as the result of Congressional direction to continue support of ongoing activities in the following program areas: advanced turboprop systems, general aviation/commuter engine technology, broad property fuels, and the energy efficient engine.

QUESTION R-3:

Please tabulate, for fiscal year 1982 through 1988, runout costs of the current aeronautics program (broken out in the following categories: CTOL(non ACEE), CTOL (ACEE), G/A, Rotorcraft, VTOL, STOL Commuter Aircraft, High Performance, Supersonic, Hypersonic, and Generic R&T). Also, to permit relating this to the standard budget sublines, please provide a further breakout, for each category, showing funds included in the R&T base, and the various Systems Technology Programs identified by budget sub-line item and further identified by program (e.g. Subsonic Aircraft System Technology under ACEE, and EET under Subsonic Aircraft System Technology).

ANSWER R-3:

See the enclosed table.

QUESTION R-4:

Please provide a tabulation for each large development program (former experimental programs plus new efforts of comparable scope) showing:

a. Original estimated date of completion and cost
b. Estimated date and cost of completion furnished to the Subcommittee last year
c. Current estimates
d. Reasons for change from last year.

ANSWER R-4:

See the enclosed table.

FY 1984 AERONAUTICS BUDGET
($ in Millions)

	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88
AERONAUTICS RESEARCH AND TECHNOLOGY	264.8	280.0	300.3	314.2	308.0	307.6	286.6
505 Research and Technology Base	172.7	197.7	227.8	227.8	227.8	227.8	227.8
Systems Technology Programs	92.1	82.3	72.5	86.4	80.2	79.8	58.8
510 Materials & Structures Systems Technology	1.6	-	-	-	-	-	-
510-54 Integ. Prog. for Aerospace Veh. Design	1.3	-	-	-	-	-	-
510-55 Aeroelasticity of Turbine Engines	0.3	-	-	-	-	-	-
511 Propulsion Systems Technology	0.5	-	-	-	-	-	-
511-58 Helicopter Transmission Technology	0.5	-	-	-	-	-	-
512 Avionics & Flight Control Systems Tech.	1.3	-	-	-	-	-	-
512-54 Advanced Guidance & Control Sys. Tech.	1.3	-	-	-	-	-	-
532 Rotorcraft Systems Technology	21.7	22.3	27.6	20.5	12.3	16.9	4.9
532-01 Guidance and Navigation	1.4	1.5	1.6	1.6	1.6	1.6	1.6
532-02 Powered Lift Technology	0.3	-	-	-	-	-	-
532-03 RSRA Flight Research/Rotors	6.0	5.0	3.3	3.3	3.3	3.3	3.3
532-04 Tilt Rotor Systems Technology	2.6	-	-	-	-	-	-
532-06 Advanced Rotorcraft Technology	11.4	15.8	14.7	9.6	1.4	-	-
532-09 Technology for Next Generation Rotorcraft	-	-	8.0	6.0	6.0	12.0	-
533 High-Performance Aircraft Systems Tech.	13.8	15.0	19.9	19.9	19.9	19.9	19.9
533-02 High-Performance Flight Research	6.2	9.2	8.7	8.7	8.7	8.7	8.7
533-03 Highly Maneuverable Aircraft Tech.	1.6	0.2	-	-	-	-	-
533-04 Turbine Engine Hot Section Tech.	6.0	5.6	11.2	11.2	11.2	11.2	11.2
534 Subsonic Aircraft Systems Technology	27.0	17.0	5.0	21.0	23.0	18.0	13.0
534-01 Laminar Flow Control	8.0	3.0	-	-	-	-	-
534-02 Energy Efficient Transport	1.5	3.0	-	-	-	-	-
534-03 Composite Primary Aircraft Structures	8.9	6.0	-	-	-	-	-
534-04 Adv. Transport Operating Sys. (Prev. TCV)	8.6	5.0	-	-	-	-	-
534-06 Advanced Composite Structures Tech.	-	-	5.0	21.0	23.0	18.0	13.0
535 Advanced Propulsion Systems Technology	26.2	28.0	-	-	-	-	-
535-01 Energy Efficient Engine	16.2	7.0	-	-	-	-	-
535-03 Advanced Turboprop Systems	10.0	15.0	-	-	-	-	-
535-05 General Aviation/Commuter Engine Tech.	-	3.0	-	-	-	-	-
535-06 Broad Property Fuels	-	3.0	-	-	-	-	-
536 Numerical Aerodynamic Simulation	-	-	20.0	25.0	25.0	25.0	21.0
536-01 Numerical Aerodynamic Simulation	-	-	20.0	25.0	25.0	25.0	21.0

AERONAUTICAL RESEARCH AND TECHNOLOGY
SPECIAL ANALYSIS
($ in Millions)

	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88
* Subsonic (Non-ACEE)	25.4	18.9	17.7	33.7	35.7	30.7	25.7
Research and Technology Base	16.8	10.9	12.7	12.7	12.7	12.7	12.7
Subsonic Aircraft R&T	13.5	7.5	9.0	9.0	9.0	9.0	9.0
Human Factors R&T	3.3	3.4	3.7	3.7	3.7	3.7	3.7
Subsonic Aircraft Systems Technology	8.6	5.0	5.0	21.0	23.0	18.0	13.0
Advanced Transport Operating Sys. (Prev. TCV)	8.6	5.0	-	-	-	-	-
Advanced Composite Structures Technology	-	-	5.0	21.0	23.0	18.0	13.0
Advanced Propulsion Systems Technology	-	3.0	-	-	-	-	-
General Aviation/Commuter Engine Technology	-	3.0	-	-	-	-	-
Subsonic (ACEE)	44.6	34.0	-	-	-	-	-
Subsonic Aircraft Systems Technology	18.4	12.0	-	-	-	-	-
Laminar Flow Control	8.0	3.0	-	-	-	-	-
Energy Efficient Transport	1.5	3.0	-	-	-	-	-
Composite Primary Aircraft Structures	8.9	6.0	-	-	-	-	-
Advanced Propulsion Systems Technology	26.2	22.0	-	-	-	-	-
Energy Efficient Engine	16.2	7.0	-	-	-	-	-
Advanced Turboprop Systems	10.0	15.0	-	-	-	-	-

* Subsonic Aircraft includes General Aviation and Commuter Aircraft.

	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88
Rotorcraft	41.6	45.3	50.9	43.8	35.6	40.2	28.2
Research and Technology Base	20.2	23.0	23.3	23.3	23.3	23.3	23.3
Rotorcraft R&T	20.2	23.0	23.3	23.3	23.3	23.3	23.3
Rotorcraft Systems Technology	21.4	22.3	27.6	20.5	12.3	16.9	4.9
Guidance and Navigation	1.4	1.5	1.6	1.6	1.6	1.6	1.6
RSRA Flight Research/Rotors	6.0	5.0	3.3	3.3	3.3	3.3	3.3
Tilt Rotor Systems Technology	2.6	-	-	-	-	-	-
Advanced Rotorcraft Technology	11.4	15.8	14.7	9.6	1.4	-	-
Technology for Next Generation Rotorcraft	-	-	8.0	6.0	6.0	12.0	-
High-Performance	42.8	52.2	58.5	58.5	58.5	58.5	58.5
Research and Technology Base	29.0	38.0	38.6	38.6	38.6	38.6	38.6
High-Performance Aircraft R&T (incl. V/STOL)	29.0	38.0	38.6	38.6	38.6	38.6	38.6
High-Performance Aircraft Sys. Tech.	13.8	14.2	19.9	19.9	19.9	19.9	19.9
High-Performance Flight Research	6.2	8.4	8.7	8.7	8.7	8.7	8.7
Highly Maneuverable Aircraft Tech.	1.6	0.2	-	-	-	-	-
Turbine Engine Hot Section Tech.	6.0	5.6	11.2	11.2	11.2	11.2	11.2
STOL	0.3	0.8	-	-	-	-	-
Rotorcraft Systems Technology	0.3	-	-	-	-	-	-
Powered Lift Technology	0.3	-	-	-	-	-	-

	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88
High-Performance Aircraft Systems Tech.	-	0.8	-	-	-	-	-
High-Performance Flight Research	-	0.8	-	-	-	-	-
Generic	110.1	128.8	173.2	178.2	178.2	178.2	174.2
Total	264.8	280.0	300.3	314.2	308.0	307.6	286.6

Funding for the following categories is included in the R&T Base programs indicated and is therefore nonadditive.

	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88
SUPERSONIC	6.3	5.6	6.0	6.0	6.0	6.0	6.0
Research and Technology Base	6.3	5.6	6.0	6.0	6.0	6.0	6.0
Fluid and Thermal Physics R&T	0.4	1.0	1.0	1.0	1.0	1.0	1.0
Propulsion Systems R&T	3.0	1.4	1.5	1.5	1.5	1.5	1.5
Materials and Structures R&T	1.1	0.6	0.7	0.7	0.7	0.7	0.7
High-Performance Aircraft R&T	1.8	2.6	2.8	2.8	2.8	2.8	2.8
HYPERSONIC	4.7	5.8	5.7	5.7	5.7	5.7	5.7
Research and Technology Base	4.7	5.8	5.7	5.7	5.7	5.7	5.7
Fluid and Thermal Physics R&T	0.3	0.5	0.5	0.5	0.5	0.5	0.5
Propulsion Systems R&T	2.3	-*	-	-	-	-	-
Materials and Structures R&T	1.2	0.7	0.8	0.8	0.8	0.8	0.8
High-Performance Aircraft R&T	0.9	4.6	4.4	4.4	4.4	4.4	4.4

*Included in High-Performance Aircraft R&T beginning in FY 1983.

QUESTION R-5:

Please provide quantitative data that traces the development of the FY 1984 budget request. Specifically, please show initial and final OAST recommendations, the submission to OMB and the request to Congress for new initiatives.

ANSWER R-5:

See the enclosed table.

QUESTION R-6:

Please provide the budget "levels" broken out by sub-line item, for fiscal years 1984 through 1988 that were provided to OMB. Also, please provide brief descriptions of the work in each level.

ANSWER R-6:

See the enclosed table.

MAJOR AERONAUTICS PROGRAMS: TOTAL COST/SCHEDULE CHRONOLOGY
($ in Millions)

	ORIGINAL ESTIMATE		JAN. 1982 ESTIMATE		CURRENT ESTIMATE		
	DATE OF COMPLETION	COST	DATE OF COMPLETION	COST	DATE OF COMPLETION	COST	REASON FOR CHANGE FROM LAST YEAR
Energy Efficient Engine	1983	178.9	1983	173.9	1983	185.8	Congressional action provided additional funding in FY 1982 and FY 1983 to complete the program. The current schedule reflects completion at the end of 1983.
Highly Maneuverable Aircraft Technology	1978	18.1	1983	27.5	1983	27.4	Due to difficulties encountered during the initial phase of the flight test program, the original date for completion was extended. The current estimate reflects decisions to reduce program scope and accelerate its completion.
Composite Primary Aircraft Structures	1985	147.5	1982	92.9	1983	102.9	Congressional action provided additional funding in FY 1982 and FY 1983 to allow the program to continue. The current schedule reflects completion of this program at the end of 1983.

CHRONOLOGY OF FY 1984 AERONAUTICS BUDGET
($ in Millions)

	OAST RECOMMENDATION	SUBMISSION TO OMB	SUBMISSION TO CONGRESS
ONGOING	288.4	294.9	267.3
R&T Base	229.5	234.7*	227.8
Systems Technology	58.9	60.2*	39.5
Rotorcraft Systems Technology	19.2	19.6	19.6
High-Performance Aircraft Systems Technology	19.5	19.9	19.9
Subsonic Aircraft Systems Technology	11.7	12.0	-
Advanced Propulsion Systems Technology	8.5	8.7	-
NEW INITIATIVES	75.0	49.0	33.0
R&T Base Augmentation	5.0	5.0	-
Numerical Aerodynamic Simulation	20.0	20.0	20.0
Advanced Composite Structures Technology	5.0	5.0	5.0
Small Engine Component Technology	4.0	4.0	-
Technology for Next Generation Rotorcraft	8.0	8.0	8.0
Large Rotorcraft Technology	8.0	2.0	-
Advanced Turbofan Research	7.0	5.0	-
High-Performance Aircraft Technology	14.0	-	-
Integrated Digital/Electric Aircraft Technology	4.0	-	-
TOTAL	363.4	343.9	300.3

* Increase reflects recalculation of price escalation between FY 1983 and FY 1984.

AERONAUTICAL RESEARCH AND TECHNOLOGY
FY 1984 OMB BUDGET SUBMISSION
($ in Millions)

REQUESTED LEVEL	FY 84	FY 85	FY 86	FY 87	FY 88	Description
Aeronautical Research & Technology	343.9	375.1	374.9	359.5	348.5	
Ongoing Program	294.9	281.1	272.9	271.5	271.5	
Research and Technology Base	234.7	234.7	234.7	234.7	234.7	Generic and vehicle-oriented research & technology
Rotorcraft Systems Technology	19.6	14.5	6.3	4.9	4.9	Rotorcraft and flight investigations
High-Performance Aircraft Systems Technology	19.9	19.9	19.9	19.9	19.9	High-Performance Flight Research and Turbine Engine Hot Section Technology
Subsonic Aircraft Systems Technology	12.0	12.0	12.0	12.0	12.0	Laminar Flow Control and Advanced Transport Operating Systems
Advanced Propulsion Systems Technology	8.7	-	-	-	-	Advanced Turboprop Systems

	FY 84	FY 85	FY 86	FY 87	FY 88	DESCRIPTION
New Initiatives	49.0	94.0	102.0	88.0	77.0	
Research and Technology Base	5.0	5.0	5.0	5.0	5.0	
Augmentation	5.0	5.0	5.0	5.0	5.0	Aviation Safety and Operating Systems
Rotorcraft Systems Technology	10.0	20.0	24.0	14.0	13.0	
Technology for Next Generation Rotorcraft	8.0	16.0	22.0	14.0	13.0	Technology development and modification of an RSRA vehicle to accept and flight test an X-wing rotor system in order to explore the start-stop phase of flight at 200-300 knots. Investigation of advanced structural, aerodynamic, propulsion, and control concepts for advanced tilt rotor technology.
Large Rotorcraft Technology	2.0	4.0	2.0	-	-	Validation of the analytical methodology necessary for doubling the payload capacity of future civilian and military operational helicopters.

	FY 84	FY 85	FY 86	FY 87	FY 88	Description
Subsonic Aircraft Systems Technology	5.0	21.0	23.0	18.0	13.0	
Advanced Composite Systems Technology	5.0	21.0	23.0	18.0	13.0	Development of composite wing and fuselage concepts and designs, and evaluation of new resins and fibers to achieve weight reduction in large primary airframe structures.
Advanced Propulsion Systems Technology	9.0	23.0	25.0	26.0	25.0	
Small Engine Component Technology	4.0	9.0	11.0	12.0	11.0	Development of advanced component technologies for application to rotorcraft, commuter and general aviation aircraft, gas turbine engines, and cruise missiles.
Advanced Turbofan Research	5.0	14.0	14.0	14.0	14.0	Advanced technology development and evaluation for fuel-efficient and economical subsonic turbofan engines for transport applications.

QUESTION R-7:

How much is contained in the Fiscal 1984 request for alternative fuels utilization research, aircraft noise research, wake vortex alleviation, heads-up display research, Cockpit Display of Traffic Information, scarce materials research, human factors, avionics, and controls?

ANSWER R-7:

	FY 1984 ($ in Millions)
Alternative fuels research	2.5
Aircraft noise research*	8.6
Wake vortex alleviation	0.8
Heads-up display research	-
Cockpit display of traffic information	1.3
Scarce materials research	1.6
Human factors	11.2
Avionics	3.0
Controls	7.5

*This includes noise research for rotorcraft and turboprop powered aircraft.

APPENDIX II

The American Society of Mechanical Engineers

2029 K Street, N.W., Washington, D.C. 20006/(202) 785-3756

Comments on

THE FY-1984 NASA Authorization Request

Submitted to the

Subcommittee on Transportation, Aviation & Materials
Committee on Science & Technology
U.S. House of Pepresentatives

March 15, 1983

Mr. John W. Robinson, Chairman
Aerospace Division
The American Society of Mechanical Engineers

Mr. Phillip J. Legendre
Member & Former Congressional Fellow
The American Society of Mechanical Engineers

INTRODUCTION

The American Society of Mechanical Engineers (ASME) is an educational, scientific and charitable society founded over 100 years ago with a membership exceeding 100,000 mechanical engineers. Because of the variety of applications of mechanical engineering, approximately 20 percent of our membership is directly involved in the aerospace industry. Many more are involved as second and third tier contractors. Traditionally we prefer to comment on technical issues, and in as much as they relate to such issues, we are pleased to comment today on the programmatic aspects of the FY-84 NASA budget as it applies to the Numerical Aerodynamic Simulator and to the Composite Aircraft Structures programs within the Aeronautical research and technology budget.

We are pleased to support the NASA budget process in these times of tightly constrained budgets and hope that our comments, now and in the future, will be of value to this Subcommittee. We believe that as working engineers and developers of future engineers we have a responsibility to support and develop technology by contributing to public awareness of the subject as we know it.

In general, we are pleased to see the funding increases in the total proposed NASA Aeronautical Research and Technology budget. We are particularly pleased with the Administration's attitude towards the NASA Aeronautics programs and the NASA/Aeronautics Industry relationship as outlined in the November 1982 White House review of federal policy on aeronautics research and technology.

We are concerned, however, with the Administration's proposed cut in the systems technology programs, although we realize that the proposed FY-84 cuts are less than those initially proposed by the Administration in the FY-83 budget. (These Systems Technology Programs were funded by Congress in FY-82 at $82.3 million whereas the amount submitted to Congress in FY-83 was $50.0 million. We note that the FY-84 request is $72.5 million, $9.8 million less than the level funded last year.)

NUMERICAL AERODYNAMIC SIMULATOR

We strongly support the $20.0 million requested by the Administration for the Numerical Aerodynamic Simulator. This certainly could be one of the bigger technology pay offs we can expect in the decade of the 80's. The magnitude of this potential pay off was brought out in the U.S. Senate Subcommittee on Science, Technology and Space hearing on the NASA FY-83 budget. It was stated in the Hearing Report that the $1.5 billion C5-A rewinging program could have been avoided if the $150 million Numerical Aerodynamic Simulator had been in existence. We expect this capability to be very important in the design and development of an all-composite-structure large transport aircraft.

COMPOSITE AIRCRAFT STRUCTURES

The Lear Fan is a turbo-prop aircraft whose structure was almost entirely constructed with composite materials. These structures include the wings, tail empennages, fuselage structure and all of the skins. Thornel carbon/carbons are the primary composite materials used. The Lear Fan was designed in Reno, Navada, but the research and development funding was provided by Great Britain. As a consequence, current plans are for this U.S. designed aircraft to be manufactured in Northern Ireland, not the U.S.A. The Lear Fan is expected to be certified in 1983.

In the U.S., NASA, DOD and the aircraft industry are currently engaged in the development of composite structures for aircraft. Secondary structures have been fabricated and tested by NASA sponsored programs. These structures include a B-727 elevator, a B-737 stablizer, a DC-10 rudder, a DC-10 fin, an L-1011 aileron and an L-1011 fin.

The AV-8B aircraft contains about 26% composite structure by weight. The F-18 airframe contains 12 to 13% composite structure by weight. The B-1 empennages have been built using composite materials. The U.S. Air Force is currently developing an outer wing box for the C5 which is to be constructed of composite materials. This development, however, is five to ten years away from production.

Tertiary Structures have been developed and are being incorporated into the latest generation airliners, i.e., the B-757 and B-767. The U.S. Army Advanced Composite Airframe Program is working on a composite structure point design for helicopters. Despite these many composite structure efforts, the U.S. is not progressing very rapidly towards an all composite structure aircraft. Yet, the next generation fighter is expected to require 35 to 60% by weight of composite structure; and, if that fighter is a "swept-forward" concept, a composite wing will be required.

In July 1982, a government/industry assessment of advanced composites was held in Dayton, Ohio. It was the opinion of those attending that the U.S. possessed the technology to design and build a composite-structure wing for a large transport aircraft. The expected cost of this development would be over $100 million. It was also the opinion of the attendees that the U.S. did not yet possess the technology to design and build a composite fuselage for a large transport aircraft.

In order to build a large composite structure aircraft wing, "tape" laying machines and large, evacuated ovens called autoclaves are required. The largest tape laying machine in the U.S. is 15 feet by 50 feet-- a large aircraft wing will require a 15 foot by 150 foot machine. In addition, the largest autoclaves are 21 feet in diameter and 50 to 60 feet in length. An autoclave with 50 foot diameter and 150 foot length is required for a large transport aircraft wing.

Why do we need the all-composite-structure aircraft? We believe this capability is necessary so our commercial aircraft industry will have the technologic[illegible] edge to produce the most cost-effective transports in the world.

This capability should enable the U.S. aircraft industry to compete in the business and private aircraft markets as well as the commuter aircraft market. In the long term, these aircraft composite structure techniques will find shipboard, automotive, truck, military vehicle, and train applications. It is conceivable that a large U.S. composite structure industry will eventually replace part of the U.S. steel industry. It may be that the blue collar worker required in the steel industry will find work in composite structure manufacturing and that closed steel plants might be reconfigured for the manufacture of large composite structures, vehicles etc.

FUNDAMENTAL RESEARCH AND TECHNOLOGY DEVELOPMENT

The return of needed development in propulsion technology and other important long-lead, high-risk technology areas including large composite structures and the numerical aerodynamic simulator mentioned before is reassuring. We believe NASA should continue to provide for technology advances essential to U.S. leadership in aeronautics. Basic research in applied fluid and thermal physics in support of internal, computational fluid dynamics and such vital government capabilities as the new advanced transonic windtunnel at Langley Research Center are extremely important in achieving a competitive edge in the world marketplace.

SUMMARY & RECOMMENDATIONS

SUMMARY

The Numerical Aerodynamic Simulator is a vital program. We endorse its funding. We do not believe the $5 million requested by NASA is sufficient if the U.S. is going to develop an all-composite-structure aircraft in a reasonable and competitive time frame.

RECOMMENDATIONS

We recommend that the funding for NASA Aeronautical Research and Technology be sufficient to accomplish the following:

1) Develop the technology to design and build a large aircraft composite structure fuselage.

2) Work towards the ultimate goal of constructing a (prototype) large transport aircraft of composite material by 1990.

3) Continue to pursue research and technology in critical areas and maintain vital government test facilities to provide advances essential to U.S. leadership in aeronautics.

This Statement was prepared by a task force of the Aerospace Division of the American Society of Mechanical Engineers. It represents the considered judgment of this task force rather than an official position of ASME.

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	FY 84	FY 85	FY 86	FY 87	FY 88	Description
Numerical Aerodynamic Simulation	20.0	25.0	25.0	25.0	21.0	Development of a large computational system composed of a large-scale computational engine and an extensive user-friendly support processing network. Will be used in all phases of computational aeronautical research and development.